GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

ALFRED R. C. SELWYN, C.M.G, LL.D., F.R.S., DIRECTOR.

ANNUAL REPORT

(NEW SERIES)

VOLUME II.

1886.

PUBLISHED BY AUTHORITY.

MONTREAL:
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1887.

PRICE, WITH MAPS, $2.00.

GEOLOGICAL & NATURAL HISTORY SURVEY.
Alfred R. C. Selwyn, LL.D., F.R.S., Director.
MUSEUM AND OFFICE, SUSSEX ST., OTTAWA.

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GEOLOGICAL AND NATURAL HISTORY SURVEY

OF CANADA.

REPORTS AND MAPS

OF

INVESTIGATIONS AND SURVEYS.

To the Honourable

Thomas White, M.P.,

Minister of the Interior.

Sir,—In compliance with Sect. 3 of the Act 40 Vic., Chap. 91 I have the honor to submit the Annual Report of the Geological and Natural History Survey of Canada for 1886, being Vol. II. New Series. As on previous occasions it embodies the results of some of the work of preceding years, and not all of the work of the year for which it is dated. This cannot be avoided, and is incidental to all scientific surveys.

The volume consists of 13 parts separately paged and lettered, and relating to various portions of the Dominion from Nova Scotia to British Columbia, and northward to the Arctic Ocean. The parts have been issued separately with accompanying maps and illustrations in pamphlet form as they were received from the printers.

I have the honour to be,

Sir,

Your obedient servant,

ALFRED R. C. SELWYN,

Ottawa, 31st December, 1887. *Director.*

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NOTE.—Maps 3, 4, 5, 6, 6A and 7 will be issued shortly in separate envelopes.

*2nd copy flat in Map room at: G 3452.E1 .C5 253 1887

ERRATA.

Page 26 B, line 7, *for* Belonites *read* Balatonites.
" 73 B, " 25, " " " "
" 83 B, " 19, " " " "
" 83 B, " 20, " A. Vancouverensis *read* Celtites Vancouverensis.
" 36 B, foot note, *for* 1876 *read* 1886
" 26 G, line 22 from top, *for* Muckitat *read* Muckitai.
" 32 G, " 9 from top, *for* north *read* mouth.
" 35 G, " 10 from bottom, *for* 02° *read* 20°.

NOTE.—The river referred to as the Weenisk on pages 22 and 30, following the spelling on the published maps, is called the Wainusk by the Indians, which means the Woodchuck or Ground-hog (*Arctomys empetra, L.*)

Page 21 J, line 11 from bottom, *for* northeast *read* northwest.
" 46 J, " 6 from bottom, *for* and *read* of.
" 61 J, " 7 from bottom, *for* old *read* new.
" 67 J, " 9 from bottom, *for* new *read* old.
" 70 P, " 1 from bottom, *for* 1872-73 *read* 1873-74.
" 104 P, " 7 from top, *for* river *read* road.
" 115 P, " 6 from bottom, *for* 182 *read* 438.
" 115 P, " 8 from bottom, *for* 1879 *read* 1873.
" 133 P, " 14 from bottom, *for* Tor *read* Fox.
" 129 P, " 10 from bottom, *for* McDonald *read* Anderson.
" 137 P, " 12 from top, *for* 70°–70° *read* 60°–70°.
" 137 P, " 22 from top, *for* being *read* been.
" 150 P, " 24 from top, *for* broad synclinal *read* broad transverse synclinal.
" 155 P, " 19 from top, *for* west *read* east.
" 155 P, " 24 from top, *for* Indian *read* Wine.
" 157 P, " 2 from top, *for* Methiffs *read* Metkiff's.
" 157 P, " 20 from bottom, *omit* Brook.
" 157 P, " 19 from bottom, *for* r *read* a.
" 157 P, " 14 from bottom, *omit* at Moorehead and Harrigan Cove Mine.
" 157 P, " 2 from bottom, *omit* fourth.
" 160 P, " 14 from top, *for* a little to the south of the first fork, *read* at the first fork.
" 161 P, " 14 from top, *for* junction *read* Junction.
" 7 S, in table, *for* $5,017,225 value of coal *read* $4,017,225.
" 8 S, note below table, *for* oil *read* silver, *and add* and oil from Ontario.
" 23 S, in table, *for* 6,478 tons in 1884 *read* 306,478.
" 29 S, last column of table, last three figures are mills.
" 32 S, fifth line from bottom, *for* 1847 *read* 1835.
" 41 S, sixth line, *for* orgings *read* forgings.
" 57 S, *for* 1866 *read* 1886.
" 65 S, fourth line below table, *for* and *read* plus that.
" 65 S, in table C, *instead of* 38,600 tons in 1884 *read* 39,600.
" 70 S, table K, *for* cwts. *read* lbs.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

SUMMARY REPORT

OF THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR

1886.

BY

THE DIRECTOR.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1887.

SUMMARY REPORT

OF THE

OPERATIONS OF THE GEOLOGICAL SURVEY.

FOR THE YEAR 1886.

The present Summary Report is a reprint, with some additions and alterations of Part III of the Report of the Department of the Interior for 1886, in which the detailed reports and the maps now presented are referred to, together with others the publication of which it has been found desirable to defer, pending further study and surveys in the districts to which they relate.

Especial thanks are due from the Survey to Mr. Joseph Wrigley, Chief Commissioner of the Hudson's Bay Company, for letters to the officers at the various posts visited by the parties working in the region north of Lake Superior and around Hudson's Bay, and also to the officers themselves for their uniform kindness and valuable assistance in various ways.

On the 9th of February I left Ottawa for England, to superintend the unpacking and arrangement of the collections sent to illustrate the mineral, vegetable and animal resources of the Dominion, at the Colonial and Indian Exhibition. I arrived in London on the 22nd of February, and a few weeks later, was joined by my colleagues, Messrs. Macoun, Adams and Willimott.

In reference to some of the practical results which may be expected, or have already arisen from the work of the Exhibition, the following facts may be mentioned:—

Plumbago—Enquiries were constantly being made about this mineral by persons from various parts of the United Kingdom, as well as from the continent. They were referred to the various exhibitors, whose addresses were given them.

Mica—A number of similar enquiries were made.

Soapstone.—Two or three gentlemen who are very anxious to find localities from which they can get continuous supplies of good soapstone, were given samples from Canada, which gave such satisfaction that one gentleman ordered five tons to make further trials, and they have all promised to report on the qualities of the samples supplied them, and will state in what essential the stone is deficient. The precise article required by the trade will thus be ascertained, and a considerable business in this material will, in all probability, be developed.

Asbestos.—There was a fine exhibit of this mineral; much attention was attracted by it, and many enquiries were made concerning it. Several asbestos properties were sold as a result of the information given. These various refractory minerals attracted especial attention.

Chrome Iron Ore—Samples of several of the specimens exhibited were sent to large consumers for examination. It was found that some would sell for about £4 stg. a ton in Glasgow, while others which were not sufficiently rich to pay for exportation might be made so by a process of careful selection, or by the ore improving in depth. Now that the Eastern Townships have greatly increased railroad facilities, and that it is ascertained that this mineral will bring remunerative prices, it will doubtless ere long be largely exported.

The gold and silver ores of British Columbia, Ontario, Nova Scotia and Quebec also attracted much attention. As a result of the exhibition, several mines have been sold, and preparations are being made for working others. Reports from the Port Arthur district show that a direct impetus has been given to gold and silver mining in that district by the Exhibition.

In this connection another very valuable result of the Exhibition is that some firms in England have made arrangements to purchase and concentrate the tailings of the principal Nova Scotia gold mines, shipping the concentrate to England for treatment. This kind of work has heretofore been carried on almost entirely in Germany.

Iron Ores.—The Iron and Steel Institute made a careful examination of the various iron ores and coals of the colonies and India represented in the Exhibition and issued a report on their iron-making resources. Out of a total of 137 pages, no less than 69 were devoted to Canada, and much attention was in this way drawn to our iron ores, which were very highly spoken of. "It requires," the report says, "no great degree of prophetic instinct to see that before long, Canada,

India, New South Wales, New Zealand, and Queensland are destined to become in a greater or less degree friendly rivals with us in competing for their own and neighboring markets." After the reading of the report, the members of the Institute visited the Exhibition and examined the ores and fuels. The ores from British Columbia, which are in proximity to coal, were the especial objects of enquiry, and it is stated that large works for the production of iron and steel will shortly be erected in that province.

A mining engineer called and asked to see our samples of these ores, stating that he was about to leave for British Columbia to erect iron works, &c., to cost some three million dollars.

Manganese.—Many enquiries were made about this mineral, and the addresses of the producers in Canada were given.

Petroleum.—Experts who were found to be much prejudiced against Canadian oil say that the samples shown them were as good as could be desired and quite free from bad smell. The Exhibition will, no doubt, help to remove this prejudice.

Ochres.—Samples were sent by request to various large consumers who will examine them and report on the prices they would bring in the English market.

Slate.—Rockland slate and slate manufactures were very highly commended, and said to compare very favorably with the best qualities of Welsh and Scotch slate.

Rocks.—There were many enquiries about Canadian granites and marbles. The red granites and the grey Arnprior marbles were much admired; and it is expected that business will be done in New Brunswick granite.

Agates, &c.—Enquiries have also been made by several firms who manufacture agate goods, respecting the agates from Nova Scotia and Lake Superior. The addresses of persons who could supply them were given. The Huronian red jasper conglomerate also attracted much attention and enquiry.

Phosphate.—The attention directed to this mineral by the fine specimens exhibibited—the only ones in the exhibition—has given an impetus to this industry, and resulted in the sale of several properties.

Reports, &c.—The special Descriptive Catalogue of the Economic Minerals of Canada, already referred to, was widely distributed at the

Exhibition. Detailed articles on the mineral wealth of the Dominion appeared in many of the principal papers and magazines. Lectures were given in the conference room on the natural resources of the Dominion, both mineral, vegetable and animal, while during the whole period of the Exhibition either Professor Macoun, Mr. Adams, Mr. Willimott or I was in attendance to answer the many enquiries which were daily being made respecting the climate, the geography, the geology and the natural productions of the country.

My best thanks are due to my colleagues above named for their hearty and zealous co-operation and valuable assistance in the work above referred to, and in arranging the large quantity of material which had to be dealt with, in such a manner as to make a successful and attractive display of the varied resources of the Dominion.

After the close of the Exhibition, on the 10th of November—except a few specimens that had to be returned to their respective owners—the whole of the minerals and some of the natural history specimens were packed up to be made over to the authorities who represent the interests of the proposed Imperial and Colonial Institute. The valuable collection of birds and other animals purchased, or supplied from the Museum collections were all carefully packed to be returned to Ottawa, where they will be properly cared for, and be available for future exhibitions.

During my absence in England in connection with the Colonial and Indian Exhibition from the 9th of February to the 22nd of December, Dr. G. M. Dawson has superintended the work of the survey as Acting Director, and his time was so fully occupied in attending to the shipment of the mineral exhibits, in work connected with the preparation of the special catalogue printed subsequently under my superintendence in London, in editing the annual volume of Survey Reports, in completing and publishing his own report on a portion of the Rocky Mountains, in making preliminary arrangements connected with the collection and compilation of mineral and mining statistics, and in the general routine and office duties, that he found it impossible to undertake any work in the field. I wish here to record my high appreciation of the very able and efficient manner in which Dr. Dawson has performed all the work above referred to.

Captain G. Geddes has during the present year put the collection of insects purchased from him in 1885 into a complete state of arrangement. Special acknowledgment is due in this connection to Mr. James Fletcher for his services in checking and verifying the nomenclature of the entire collection, an operation requiring much labor and time. An important addition has been made to the museum by the purchase of the ethnological collection of Mr. François Mercier, a

collection of representative character gathered by him in the course of a number of years' residence on the Yukon River. The Museum now contains a good typical collection of the arts and manufactures of the tribes of the west coast, from Vancouver Island to the Arctic Ocean.

The title of the detailed report of the Survey was in the last issue changed from that of "Report of Progress" to "Annual Report" and the present issue is the second volume of this new series. A certain number of copies of each report has been printed separately, and though involving more labor in regard to distribution, and some additional expense, the plan has already proved to have many advantages, particularly in enabling the public to obtain, at a nominal cost, the information respecting any particular district.

The requirements of the Survey in respect to increased museum and office accommodation become each year more pressing, and the cramped condition and limited accommodation afforded by the building at present occupied is now such as in some instances to seriously embarrass the work in progress. It is respectfully submitted that an office of such capacity is required as would enable the apportioning of a separate room to each officer entrusted with the work in a particular district, while the museum building should have a character more proportionate to the value of the collections and more creditable to the Dominion. Several plans have been suggested by which the requisite additional accommodation could be secured at a comparatively small outlay, and I venture to hope that the matter will shortly receive the favorable consideration of the Government, more especially as the risk in the present building of the total destruction of the collections by fire is very great.

It will be observed that during the past season the field work was in progress in eleven districts, and that in some of these, in addition to the work by the head of the party, independent work was simultaneously in progress by one or more assistants

British Columbia and North West Territory.

In British Columbia the exploration of the most important area in the Cariboo gold-bearing district was continued by Mr. A. Bowman, the Government of British Columbia contributing as before towards the expense of this work, which involves the mapping of a very rough district in addition to its geological exploration. It is anticipated that a map and report on this district will be ready for publication next spring. Mr. Bowman gives the following details respecting the work accomplished :— British Columbia.

"In continuation of the work of 1885 in Cariboo district, I left Victoria 23rd June, accompanied by Mr. James McEvoy as geographical assistant; procured pack animals, supplies, and four additional men at the 150 Mile House, all in Cariboo district; and on Saturday, the 3rd July, started into the field.

"Our equipment this year was suited to exploration in the mountainous parts away from the waggon road and trails ordinarily travelled.

"The field covered was, in general, the same as last year, viz.: the mining region embraced between latitude 52° 40′ and 53° 40′ N. and longitude 121° to 122° W. but the work differed somewhat in character as well as in method of execution. Last year the roads and trails were measured; a waggon was used as a base of supplies in connection with three or four pack animals, the centrally situated mountains were occupied as triangulation stations, and geological and mining features were subordinated to geography. This year I was also able to entrust most of the geographical work to Mr. McEvoy. Although our parties were equipped to move independently of each other, we generally worked together, or near each other, and my attention to the geographical work was only directed to its general progress and final completion in connection with my own investigations. From this must be excepted, however, those parts of the country visited exclusively by my party, and all the details of the geological work to be fitted into the map.

"The Goose Creek Mountains and the Selkirk Range, where there are no trails, were traversed with shoulder packs, relying on the rifle, to a considerable extent, for supplies. A micrometer measurement of the great Quesnel Lake was carried out with the aid of a large Chinese boat and an Indian canoe. Bear and Swamp River Mountains and the Dragon Creek Mountains were ascended with a single pack horse, relying on the axe in lieu of a trail for progress.

"The geographical work was completed by occupying with the transit all the necessary outlying stations, and by measuring with the steel tape two independent base lines approximately fifty miles apart, situated respectively on Snowshoe Plateau and at Quesnel Mouth, which will be used as the foundation of the whole of the work.

"In the geological work pursued by myself while thus completing the observations for our map, it was the distribution of the rocks and the mining features of the country that governed, not only my own movement, but the movements of both parties. A section was made from the limestone rocks of Beaver Lake through the gold bearing series to the northern Selkirk or Inner Cariboo watershed, between Mitchell's Lake and Canoe River, near Albreda Lake. Subsequently the cherty rocks of Bear River, which occupy a prominent position in

Cariboo, were intersected at various points and in different directions. Quartz ledges adjacent to the rich placers heretofore mined were everywhere noted, examined and sampled for assay.

"As results of the season's work I may mention the discovery of abundant evidence of the continuousness, permanence and richness of the quartz ledges of Cariboo, and of fossils in the gold bearing region, which determine the age and position of its rocks in the geological scale.

"The slates are of palæozoic age, and not improbably identical with those of Anderson River and Boston Bar on the lower Fraser, associated with the first gold mining in British Columbia, accordingly much older than the auriferous rocks in California, as determined. On the other hand I found near Quesnel Forks very good placer diggings, the gold of which is derived from rocks containing fossils of the 'Shasta Group' of the Cretaceous.

"The time occupied in field work was from June 23rd to November 6th, four months and a half." Mr. Bowmans detailed report and maps are now being prepared for publication.

In 1885 Mr. R. G. McConnell had been occupied in geologically exploring the Rocky Mountains to the north of the line of the Canadian Pacific Railway, and it became obvious as the result of this work and of that carried on by Dr. Dawson in other parts of the mountains, that a carefully examined section across the entire width of the range on some chosen line was necessary as a clue to its intricate structure. Mr. McConnell, who was instructed to undertake this examination, reports as follows on it:— North-west Territory.

"The principal object of the season's work was to obtain a more detailed section across the main Rocky Mountain range than the hasty exploratory work heretofore done has afforded; as it was considered that the knowledge thus obtained would greatly facilitate operations in more remote regions where the shortness and uncertain character of the season, combined with the difficulties in travelling, due to trails encumbered with wind-fall and crossed every few miles by swift mountain streams, which even near their sources are often well-nigh impassable, render the prosecution of geological work both tedious and expensive. The country in the vicinity of the Canadian Pacific railway was selected as the best adapted to the purpose in view, as, besides its greater accessibility, it adds the further advantage of being more accurately surveyed than any other part of the range. Work was commenced on the 24th of May, at tho Gap of the Bow River, and during the course of the summer, all the subordinate ranges lying between that point and Golden City were ascended and examined; involving altogether climbing to the extent of over 200,000 feet. In October the

weather having become too severe for further work in the mountains, a short time was devoted to the examination of the Cretaceous rocks of the eastern foot-hills in the vicinity of the Bow River. In addition to the stratigraphical work accomplished, a number of sketches and cross bearings were taken from the summits of most of the mountains ascended, which will add considerably to our knowledge of the topography of the region, and a large suite of fossils was collected from the various formations represented in the range. The results of the exploration have not been worked up yet, and cannot therefore be given in detail, but the following general statements may not be uninteresting.

"The Rocky Mountains are mainly composed of strata ranging in age from Lower Cambrian to Lower Carboniferous. Along the line examined, this series has a minimum thickness of 20,000 feet, and is apparently conformable throughout, although in other parts of the range, distinct unconformities have been detected by Dr. Dawson and by Dr. Hector. That deposition was not continuous throughout the entire period is shown by the fact that in the eastern part of the range, the Silurian is scarcely represented, although it becomes of considerable importance on approaching the Columbia. East of the main divide, the Lower Carboniferous is overlain in places by beds of Lower Cretaceous age, and here again, although the two formations differ so widely in respect to age, one overlies the other without any perceptible break, and the separation of one from the other is rendered more difficult by the fact that the upper beds of the Carboniferous are lithologically almost precisely like those of the Cretaceous. Were it not for fossil evidence, one would naturally suppose that a single formation was being dealt with. This great series of conformable strata shows that prior to the last great upheaval which gave the range its present form, the region was subjected to little disturbance and no folding or crumpling of the rocks to any appreciable extent had occurred. This fact is also further evidenced by the prevalence of one dominant type of structure. From the axis of the range to the eastern edge, the beds nearly everywhere dip regularly and usually at high angles, in towards the centre. This uniformity in dip is produced by a series of great fractures, accompanied by displacements of many thousands of feet, which have had the effect of causing the same beds to be repeated at least seven times. These faults are of great length, and run in approximately parallel lines, and as soon as, or before, one dies out it is replaced by another, a few miles distant, which continues on in nearly the same direction. The range is bounded on the east by a dislocation of such magnitude that few occurrences of a similar character elsewhere can bear comparison with it; it has affected all

the formations between the Cambrian and the Middle Cretaceous. The Cambrian limestones have been thrust forward for miles along the line of this fault and now overlie in a nearly horizontal position. the black shales of the Cretaceous. West of the axis, only one fault has been clearly made out, but the beds have been so disturbed and altered by an intrusion of igneous rock near the line of section that the structure there becomes more difficult to unravel. All the evidence collected, however, goes to show that west of the axis overturned folds and not faults play the most important part. An interesting feature of this range, and one which places it in rather an anomalous position among mountain chains is the fact that along the watershed range, and for several miles on either side of it, the beds, although folded to some extent, are less disturbed than in any other part, and in no place examined has denudation yet uncovered a granitic axis." *

Mr. J. B. Tyrrell, assisted by Mr. D. B. Dowling, was occupied during the entire summer in completing the geological exploration and examination of the country between the Bow and the North Saskatchewan River, east of the 115th meridian. A report and map of this district will be prepared during the present winter. Mr. Tyrrell furnishes the following summary of the work accomplished:—

"Acompanied by Mr. D. B. Dowling, I left Ottawa on the 10th of May and proceeded at once to Calgary, where our horses had been left in the autumn of 1885. Having there obtained men and the necessary supplies, we started eastward to the Lord Lorne Crossing of the Red Deer River where our survey began.

"Following the trail on which Lord Lorne had travelled out in the summer of 1881, we crossed Bull Pound and Berry creeks and traversing a stretch of flat 'alkaline,' country reached Sounding Creek. We there left the trail and followed the creek in its winding course for one hundred and twenty miles, till it reaches Sounding Lake, lying in the middle of the Neutral Hills. Leaving this lake and crossing the hills in a westerly direction we reached Nose Creek, which we followed northward to its confluence with Battle River, a little above the crossing of the Fort Pitt and Sounding Lake trail. The next few weeks were spent in examining the valleys through which streams run into Battle River from the north, working from east to west in order to be able to reach Edmonton about the middle of July.

"During the time we were able to define with a fair degree of accuracy the northern extension of the low anticlinals, which had already been noted by Mr. McConnel, in the region to the south, as bringing

*For further information respecting the very interesting observations on the geological structure as well as concerning the mining development in the district above briefly referred to, Mr. McConnell's detailed report and section part D. of this volume, can now be consulted.—A.R.C.S.

the sandstones and clays of the Belly River series to the surface from under the shales of the Pierre group.

"At Edmonton a boat was secured and in it I made a traverse of the North Saskatchewan as far east as Fort Pitt, while Mr. Dowling went round by the north trail with the horses and waggons, at the same time making an odometer survey of the line of travel and of as much of the surrounding country as the time at his disposal would permit. Turning west from Fort Pitt we followed in succession the Vermilion River, and other streams flowing north into the Saskatchewan, till we again reached Edmonton, thus completing our preliminary examination of the district lying south of the North Saskatchewan and between the fourth principal meridian and the Edmonton-Calgary trail.

"Our attention was then turned to the country lying to the west of this trail. We proceeded overland to Rocky Mountain House where we constructed a boat, and sending the teams back as they had come, I descended the river to Edmonton, making a geological examination of its banks, and a track-survey of those parts which had not yet been surveyed. Afterwards we went south-west to Pigeon Lake, made an examination of Battle Lake and the upper portion of Battle River; thence west to Gull and Black Lakes, the Blind Man, Medicine and Wolf rivers, returning to Calgary the eighteenth of November, when our horses were sent out to be herded and our outfit left in store for the winter.

"During the course of the season, special attention was paid to the occurrence of the different coal seams throughout the district, they having been found to underlie a very much larger extent of country than could have been thought at all probable.

"The 'Big Coal Seam' on the North Saskatchewan, for instance, was found to be on the continuation of a coal horizon stretching north westward from Knee Hills Creek and the Red Deer River, underlying country which is at present completely grass-covered, and shows no external evidence of coal anywhere in the vicinity. Along the Red Deer River, this seam has been burnt in a number of places, and the ashes which were collected at the foot of the bank have been assayed by Prof. Chapman, of Toronto, who finds that they contain small quantities of both gold and silver.*

"Besides matters of strictly geological interest, the character of the different soils has been noted, as well as the character of the grass or the timber growing thereon, so that it will now be possible to bring out a map showing the limits of the prairie and of the wooded districts, with notes on the nature of the underlying soils. Careful barometric

* Subsequent assays made in the laboratory of the Survey gave in some cases a trace of gold, but no silver. See page 33 Part T. this volume.

readings have also been taken at numerous points throughout the area examined, in order to lay down on the map contour lines, sufficiently close to show at least the general slopes of the country.

"A number of fossil remains, of plants and animals, was collected during the season, while Mr. Dowling devoted time to the collection and preservation of objects of natural history, of which mention is made on a succeeding page."

During the season, forty-three photographs were taken, illustrating the character of the country. Field work ended on the 18th of November, when the party reached Calgary.

Ontario and Hudson's Bay.

Mr. A. C. Lawson, assisted by Mr. W. H. Smith, was engaged in the geological survey of the country to the east of the Lake of the Woods, the work being devoted principally to the mapping of the sheet which includes Rainy Lake and its vicinity, but covering also portions of adjacent territory, and in the measurement of certain connecting lines which were found necessary in order to complete the geological and topographical information. **Ontario and Hudson's Bay.**

Mr. Lawson left Ottawa for field work on the 15th of June and returned from the field on the 12th of October. As the work of another season will be required to complete the information for the Rainy Lake sheet, Mr. Lawson has prepared a synopsis of the geological results so far arrived at, in some detail, as follows :—

"The season's operations were begun at Wabigoon, where Mr. Smith was intructed to carry a micrometer and compass survey from a fixed point on the Canadian Pacific railway through to Rainy Lake by way of the Manitou canoe route to connect with the system of township surveys on the Rainy River. The west side of the lake on this route was mapped in detail as far as the middle of Manitou Lake, from which point onwards both sides were embraced in the survey, being within the limits of the Rainy Lake sheet. Several weeks were next occupied by Mr. Smith in completing the survey of the north-western expanse of Rainy Lake from Coutchiching northward to the Devil's Falls. In addition to the usual micrometer and compass survey, a transit line was run between the two latter points, a basis upon which to check the variation of the compass, which does not appear to be uniform throughout the district. This done, Mr. Smith next made a survey of an important chain of lakes extending from the bottom of Redgut Bay, Rainy Lake, to Lake Manitou, which it is believed has never hitherto been explored. During the last few weeks of the season, Mr. Smith was engaged in completing certain detached surveys near

the mouth of Rainy River and in the south part of the Lake of the Woods, which stress of weather or other adverse circumstances had interfered with the previous season; so that nearly all the topographical material requisite for the mapping of the Rainy River sheet is now on hand.

"After having at the beginning of the season provided Mr. Smith with men and equipment requisite for his survey of the Manitou route, I left him at Wabigoon and proceeded to Rat Portage. Here two or three days were spent in the usual preliminary arrangements, and in inquiring into the state of the mining industry of the district, after which I proceeded to make a topographical and geological survey of the canoe route which extends from Lake of the Woods to Rainy Lake *viâ* Crow Lake and Pipestone Lake. The route consists of a chain of large lakes which have never heretofore been mapped. The west side of Crow Lake had previously been traversed by the survey, so that work was begun in the neighborhood of Turtle Portage, and carried along the south side of Crow Lake, thence through Boulders, Sand-hill and Schist Lakes into Pipestone Lake, and then through Stone-dam, Loon, Jack-fish and Foot-print lakes to the north-west bay of Rainy Lake. The survey was made by means of a Massey's patent log, the portages being chained, and was checked at various points on previous surveys. The Huronian (Keewatin) series of the Lake of the Woods was traced eastward and southward of Crow Lake, and was found to have an extensive development in those directions to a point midway between that lake and Rainy Lake; and as similar rocks are found along the Manitou route, it would appear probable that they also occupy the intermediate country between the two routes, although that is a point which has yet to be investigated. On Stone-dam Lake the Keewatin rocks give way to granitoid gneisses. The gneisses continue through to Rainy Lake, and it was here observed that they exhibited a more decided tendency towards a differentiation than has hitherto been noticed throughout the region. The two types into which the gneiss here resolves itself are a rather massive syenite gneiss and a more distinctly laminated biotite gneiss. An attempt was made to trace out this differentiation, not only on the Pipestone route, but also on the western shores of Rainy Lake, by subjecting them to a more critical examination than had been given them at the time of their topographical survey during the previous season. This attempt met with some measure of success, and it was found that throughout the field there can be distinguished as regards mineralogical composition:—

1. (*a*) Hornblende syenite gneiss. } With little or no quartz.
   (*b*) Mica syenite gneiss.
2. Quartzose biotite gneiss.

"Both these vary much in their texture, from coarse grained granitoid to regularly foliated gneisses. Often they are marked off from each other very distinctly, and when this is the case, the syenitic gneiss appears to occur between the quartzose biotite gneiss and the lowest member of the green schists of the Huronian (Keewatin series). At other times the quartzose biotite gneiss and the syenite gneiss are so confusedly intermixed that it is a hopeless task to attempt to separate them. Whether these two types of gneiss can be sufficiently separated to permit of a geological generalization, which would be of service in the elucidation of this great fundamental series of rocks, can only be ascertained after the field notes have been carefully plotted. The belt of Keewatin rocks which crosses the Kishcotena route between Lake Kishcotena and Lake Despair was studied in detail and traced in continuous connection with the area of the same rocks examined earlier in the summer on Crow Lake, and Pipestone Lake. Some three or four lakes, of which Kaktimiagamak Lake is the most important, were surveyed and added to the topography of this route. The geological features of the northern part of the Manitou route were mapped out by the aid of the topographical sheets supplied by Mr. Smith's survey. The section proved an extremely interesting one, revealing, among other things, an extensive fault, with which is probably associated the origin of the long, narrow, deep body of water known as Lake Manitou.

I returned to Rainy Lake by the Little Canoe route, making a log survey of the several lakes which form it, and mapping the geological features exposed on their shores. These four approximately parallel routes, the Kishcotena, the Pipestone, the Manitou and the Little Canoe, together with two others, the Little Gull Lake route and the Big Canoe River, which have yet to be surveyed and examined, afford as many parallel sections across the country by the aid of which, since they are always interlacing, it is hoped that the distribution of the different formations in this part of the field will be satisfactorily mapped.

"In the southern part of Rainy Lake some time was spent in working out the geological features of the islands and part of the south shore, as well as that portion of the north shore which required special investigation in the light of the previous season's work; and considerable additions were made to the topography. The most interesting fact brought to light is, that, whereas on the Lake of the Woods and in the northern part of the Rainy Lake district the hornblende-schists and the altered traps which constitute the base of the volcanic division of the Keewatin series are generally (though not always) in immediate contact with the granitoid gneisses, here there occurs

between the green schists and altered traps, and the fundamental gneiss, an immense development of mica-schists with some fine-grained, evenly laminated, micaceous gneiss. The underlying granitoid gneiss bears the same intrusive relation to these mica-schists as it does to the basal hornblende-schists of the Lake of the Woods. The mica-schists appear to thin out towards the north and to expand in volume to the south into Minnesota. They constitute the floor upon which the green schists and altered traps have been deposited, and their intervention between the latter and the granitoid gneiss, to a thickness of between two and three miles or even more, is a striking and conclusive argument, so far as regards this region at least, against the theory which would make lithological character a function of age, and therefore an indication of the age of non-fossiliferous rocks.

"For the purpose of acquiring a knowledge of the geological features of the south-eastward continuation of the Rainy Lake formation, and at the same time of becoming familiar in a general way with the features of the country between Rainy Lake and Thunder Bay, the last few weeks of the season were devoted to an examination of the canoe route along the Canadian side of the Minnesota boundary, and the field work was brought to a close at Port Arthur."

Mr. E. D. Ingall left Ottawa for his field of work in the Thunder Bay district on the 9th of June, returning to Ottawa on the 13th of November. He was assisted by Messrs. H. P. Brummel and J. H. Moore, and was engaged principally in continuing and completing his work previously carried out in connection with the Silver Mountain and Rabbit Mountain mining regions and adjacent territory. This work will be made the subject of a detailed report, accompanied by a map, as soon as the result can be elaborated. Mr. Ingall has prepared the following sketch of the mining developments of the district, which embodies the main results arrived at, in advance of the detailed report:—

"The new mining region to which attention is now especially directed lies west-south-west from the town of Port Arthur on Thunder Bay, Lake Superior, which place is the headquarters of the mining men and the explorers.

"The discoveries are situated along the northern fringe of a range of hills forming the southern boundary of the valleys of the Kaministiquia and Whitefish Rivers as far as the source of the latter, a distance of some 60 miles from Port Arthur.

"There are two chief centres of activity in this belt of country which is from four to six miles wide, namely, Rabbit Mountain and Silver Mountain. At these places numerous mining locations have been taken up. On some of the most promising a good deal of work

has been done toward testing, whilst on the rest, little or no developments have been made. In some cases it seems doubtful whether the purchasers were ever in the country, for many of the locations are situated in valleys where the rock must lie under a very considerable thickness of clay or even of swamp soil.

"Besides the veins that have been discovered and taken up around these two places, exploration and acquirement of locations has also gone on to a considerable extent around Whitefish Lake in the same series of rocks, and a few locations have been taken up on the supposed southern extension of the veins towards the international boundary at Pigeon River.

"The surface of the region presents a number of flat-topped hills, frequently roughly circular, separated by valleys about 200 to 300 feet deep. From the tops of the hills down, the rock is shown in cliffs varying in height from 30 to 150 feet, below which the debris fallen from above, slopes off at an angle of 45° for probably another 50 feet when it merges into the gentler slope of the clay and soil filling the valley.

"Geologically the rocks in which the veins occur belong to the Animikie Series which is presumed to be Lower Cambrian. The strip of country containing the discoveries is from two to four miles away from, and runs roughly parallel to the junction of these Animikie rocks with the granitic and other rocks to the north referred either to the Huronian, or to the Laurentian.

"The Animikie rocks of the Silver Mountain district are nearly horizontal and consist of diabase trap, black argillites and some ferruginous dolomites, chert and jasper. The diabase caps the tops of the hills and has a thickness of from 150 to 200 feet, but the hills being bevelled off all round the thickness of the rocks shown in the cliffs is only from 50 to 100 feet. Below the trap there are about 200 feet of argillites, whilst at Silver Mountain below this again are to be seen about 100 feet of the chert and jaspery beds. The depth to which these latter extend cannot be ascertained as the soil of the valleys covers up everything below this.

"The trap occurs also as intrusive sheets, and although it is most probable that dykes of this rock occur I have not as yet been able to identify any. If they exist in the Silver Mountain area they must have weathered away more easily than the other rocks and for this reason are always covered up. The reverse of this is found to be the case in the sections of these rocks shown along the coast of Lake Superior between Port Arthur and Pigeon River, where the dykes form points and even protrude as distinct walls on passing inland from the shore.

"The argillites are in places soft and black, whilst at others they are harder and siliceous, and again at others contain a small proportion of magnetite and small crystals of chiastolite.

"The lower silicious beds consist of a variety of rocks, black, white and green cherts and jaspers, the latter are found plentifully sprinkled with vermilion spots. Inter-stratified with these are irregular beds of dolomite, generally rusty colored from the presence of iron. These siliceous rocks all contain iron in varying amounts—sometimes as ferric oxide, sometimes as magnetic oxide; the latter occasionally forming such a large proportion of the rock as to constitute an iron ore. An analysis of such ore gave Mr. Hoffmann 53 per cent. of metallic iron and no titanic acid.

"The principal veins of the Rabbit Mountain district are seen to cut through similar hills of black argillites, capped by the same kind of trap, but as I have only begun a detailed examination of this latter district I cannot yet say whether the section downward is the same in detail as at Silver Mountain.

"To the north of Whitefish Lake and west of Silver Mountain is an area consisting chiefly of the siliceous group in which several veins have been discovered, whilst a few which have been located on the south side of the lake cut the argillite group.

"These lodes are true fissures, as evidenced by the way they have faulted the 'country' rock, the vertical displacement varying in different cases from a few feet up to 70 or 80 feet in one case. The lodes vary in their size and definiteness in the different beds. In the trap they are generally wide and filled with a solid mass of gangue minerals, often having in the centre large cavities or 'vugs,' lined with coarsely crystallized calcite, whilst in the argillites they are composite, breaking up into a number of branches and stringers distributed through the 'country rock,' or else they form a regular brecciated vein with the gangue minerals crystalized around the enclosed portions of the argillites. The veins which have been discovered in the lower cherty beds are generally more solid and with more definite walls than those in the argillites, and contain less silver.

"At times great difficulty is experienced in following these veins in the argillites owing to the fact that in drifting or sinking they pass from a good solid vein to portions where the ground is all split up by numerous small stringers, distributed through a large thickness of 'country' rock, so that only one or two of them can be followed. This has sometimes led to the belief that the vein had 'pinched out,' and that the veins do not continue downward. This is, however, an erroneous belief, for such very shallow fissures would hardly have produced the amount of displacement of the rocks so frequently found,

and further, one would naturally expect much local splitting up and indefiniteness of the veins in such laminated rocks as these argillites. This idea is borne out by the appearance of the veins where they cut the upper trap. This being compact, they are there large and solid. I feel sure that where there is a vein showing evidence at other points of being a 'strong' one, if followed carefully through the distributed part, it will again come together and become solid, and this has been the case in more than one instance in the region.

"The gangue or veinstone in these lodes consists mostly of barite, calcite and fluorite (green and purple) with white and ameythistine quartz. The relative proportion of these minerals varies considerably in different parts of the vein. The silver occurs in the form of argentite and native. The former is the most common, the latter, so far, seeming to be confined to the surface, or to some slight depth below it. The other metallic minerals are pyrite, blende and galena. The two latter vary in the amount of silver they carry, sometimes assaying none, sometimes yielding a considerable percentage.

"It seems to be the rule, so far, that where the vein is charged with silver, the blende and galena also carry it, although it is not visible in them, whilst, away from these places, they are as a rule either poor in silver or wholly free from it.

"The silver is usually concentrated in spots in the veins, these ore bodies being of greater or less extent and varying much in their richness, sometimes assaying even into the thousands of dollars per ton, and sometimes yielding $100 down to $10 or less per ton. Between the ore bodies there are barren stretches of greater or less extent where the vein carries either a small proportion of blende, pyrite and galena or often no metallic mineral at all. At those places where they cut the upper trap bed, the veins carry either no silver or very little.

"Although much exaggerated talk has been indulged in the locality to which one cannot subscribe, the occurrence of rich silver ores in the veins is a fact.

"I have personally visited some eight different properties where I have seen excellent ore in the veins in bodies of greater or less extent. In some cases, the quantity has been small but encouraging as an earnest of more extensive bodies yet to be discovered by underground development, whilst in others the extent of the ore has been such as to yield from $5,000 to $30,000 or perhaps more.

"The precious metal is fairly distributed in the veins. In one instance recently, I was present when some very rich ore was taken out which was full of argentite in the form of nuggets and sheet leaf, and 600 feet from this spot silver has since been found in another opening on the same vein.

"At another place, equally rich ore was discovered at a depth of 160 feet, a body of rich ore having been previously taken from the outcrop of the vein, and mill rock is now being taken out at a depth of 40 feet.

"In yet another instance very rich ore was taken out of the vein at one place and, although this did not prove extensive, further development disclosed some good ore near the first body, though sufficient work has not yet been done to judge of its extent. On the same vein, ore running about $200 to the ton has been found a mile from the first discovery.

"The chief development work in the region has been made at the following points in the Silver Mountain district:—Silver Mountain east end, Silver Mountain west end, and Crown Point, whilst in the Rabbit Mountain district the chief work has been done on the Rabbit Mountain, the Beaver and the Porcupine veins. At all of these points ore of greater or less richness and extent has been obtained. At Rabbit Mountain a mill with a daily capacity of 15 tons, is now erected to treat the ore, and has been running since first August last, whilst at the Beaver mine a similar mill, but of larger capacity, is being built. None of the mines have as yet attained a depth of more than 200 feet below the overlying trap, and they are therefore all in the argillite. The reason of this is that nearly all the veins intersect hills or ridges some 200 feet high, and it has therefore been most natural to commence by driving tunnels into the sides of these hills.

"The opening up of the region has not been nearly so rapid as it ought to have been, owing to the many disadvantages under which it has labored, of which I propose to speak at length in my detailed report.

"For these reasons the district is not yet out of its trial stage, nor will be, until there are a few mines opened up to a much greater extent than those at present existent, and we must anxiously await the confirming results of developments in depth. The question must be solved in several cases as to whether these ore bodies occur at sufficiently frequent intervals in the veins to pay for going through the intermediate stretches of poor ground, but I see no reason at present for supposing they do not.

"The region will of course have its failures as all mining districts have, and many of the veins found will never develop into rich mines; but this does not prevent it from becoming an active mining region with many successful enterprises.

"Considering the difficulties under which prospectors labor and the comparatively small amount of prospecting and development yet accomplished, I think the results are very encouraging, and were the

locality under more favorable conditions there would be ten times the amount of activity now observable. The development of the district requires not only energy, but that this energy should be rightly directed, and that a liberal policy should be pursued by the owners of mines and by the Government controlling the land; the former when without the requisite means to develop the mines, should not drive away the capitalist by counting on large sums for the mere right to work.

"Besides the possibilities of this section in the direction of silver mining there is a chance of its coming to the front as an iron producer, for the prevalence of magnetite and other forms of iron ore in the lower siliceous beds of the series raises the expectation that exploration may lead to the discovery of points where this ore occurs in sufficiently large and pure beds to be profitably worked.

"The attention of explorers has just now been turned to the question by the successful working of the iron ores lately discovered at Vermilion Lake, in the United States. These mines are situated in Minnesota and are about 120 miles west-south-west from Silver Mountain. Such has been the success attendant upon their opening that within the last two years the little town of Tower, with 2,000 inhabitants, has sprung up in the middle of the wilderness, and some 60 miles of first class railroad, now operating, connects it with the nearest shipping point on Lake Superior, and in about two months this railroad will be completed through to Duluth. At the present lake terminus of Two Harbours a little village has sprung up and there are complete docks for shipping the ore.

"The company working the mines has 1,150 men on its pay-roll at present, and is shipping 1,100 tons of ore per day, worth about $5,700, or at the rate of about $1,700,000 per annum.

"It has been pointed out to explorers and to mining men, in the Port Arthur district, that the geological features there lead to the conclusion that the iron ore deposits of Tower will be found to continue to the North-east into Canadian territory, where similar green Huronian slates occur, in contuct with the Animikie argillites.

"Somewhat similar iron ore in the Huronian green schists has been described* near the Kaministiquia station, and thence eastward through the township of Oliver the indications of the occurrence of deposits of iron ore are very marked. Mr. Peter McKellar reports the discovery of a very large iron ore deposit near the Huronian Gold Mine, but this I have been unable to visit."

Mr. E. Coste was engaged during the season of 1884 and the greater part of that of 1885, in the geological survey of sheet No 113,

* Geol. Survey Report for 1869, pp. 330.

Ontario, this sheet having been selected as that covering certain important mining districts. It includes parts of Hastings, Northumberland, Durham, Peterborough and Victoria counties.

The extremely untrustworthy character of much of the geographical and topographical information available for the part of the province in question, and the necessity of measuring and resurveying many lines in order to produce a map of sufficient accuracy for the proper delineation of the geological features, together with the geological complications which were discovered, continued to render the progress of this work much more tedious than had been anticipated. In view of these circumstances and the fact, which became evident in the course of the work, that the region immediately surrounding Madoc and Marmora required minute investigation and a very detailed survey, in order properly to establish and explain the nature and relations of the deposits of iron ore and of the auriferous mispickel and quartz veins, with the granitic and dioritic igneous masses—a relation noticed by Mr. Coste in 1884—it was considered advisable to give this particular investigation the first place in the work of the present year. Mr. Coste reports that with the assistance of Mr. J. White as topographer, a map of the Madoc and Marmora region, including an area of about 700 square miles, has now been completed on a large scale. In addition to this work, about seven weeks were spent on portions of the northern part of sheet 113 outside this particular area. The complicated outline of the edge of the Cambro-Silurian limestones on the Archæan rocks had previously been mapped across the sheet by Mr. Coste, but with the purpose of endeavoring to separate the Trenton and Black River groups of the Cambro-Silurian, Mr. H. M. Ami was requested to make a palæontological examination of these rocks, which he successfully accomplished and at the same time obtained a number of interesting sections illustrating their character. Between six and seven hundred specimens of fossils were collected in this district by Mr. Ami. Mr. Coste states that the north-east part of sheet 113 has proved to be "of extreme geological complication. Fifteen large igneous masses and numerous smaller ones are to be found there in an area of about 500 square miles. They have cut the Archæan or primitive rocks to pieces and have completely metamorphosed large areas of the rocks of that system, so much so, that I estimate these metamorphosed rocks (principally metamorphosed by injection) and the igneous masses, to occupy about half the area of the Archæan of that part of the country. This great complication has made numerous traverses absolutely necessary in the parts examined, and though I have reason to think that these eruptions are less numerous to the west in the other parts of the map occupied by the Archæan rocks, it is nevertheless certain that there also many traverses will be required."

In consequence of these facts and the uncleared and sparsely settled character of the north-western part of sheet 113, it may perhaps be found advantageous to prepare this sheet with an accompanying report, for immediate publication, leaving the details of the intrusions probably yet to be discovered for future elaboration. Respecting the detailed map above referred to Mr. Coste writes as follows :—

" Apart from the seven weeks already stated to have been spent by me this summer in the working out of sheet No. 113, the rest of my time, from the beginning of June until the middle of October was devoted to the detailed map of the Madoc and Marmora mining district, as well as the whole time, during that period, of my assistant, Mr. White, who was engaged in the topographical work. I am pleased to report that we have been able to complete the work, and that we have now a map of 40 by 40 inches on the scale of 20 chains to an inch, showing with a great many details the geographical, topographical and geological features. A complete transit and chain re-survey of the whole area under examination had to be undertaken, and was well and diligently performed by Mr. White, assisted by two men. As the work proceeded Mr. White, had to plot it in the field, to allow the geological lines to be accurately laid down, the old township maps available being of no service. Mr. White is now engaged in replotting and reducing the whole summer's work and the map to a scale of 40 chains to the inch. When geologically colored, this map will clearly prove the close proximity referred to of the iron ores and auriferous quartz veins to the igneous masses and dykes cutting the Archæan, thus giving the key for further discoveries of economic importance in the Archæan rocks which cover so large an extent of country in Canada; besides being a guide for the district itself not only to what has been done towards the development of these mineral resources, but also to what may be expected and to where new work and researches should be directed. It will further show at a glance the very uneven and undulating surface of the Archæan rocks at the time the Cambro-Silurian sea invaded the country, and the great amount of valley erosion effected since the time the sea receded."

In December Mr. Coste spent about ten days in visiting some points in the province of Quebec from which additional particulars were required for the purpose of completing information in regard to mineral statistics, and as the compilation and preparation for publication of these statistics for the current year will now be a first charge on his time, the detailed report on the Madoc and Marmora region may not be ready for publication for some months, though it is anticipated that it will form a portion of the next annual volume.

Mr. Coste's field work was begun the 21st May, and concluded on the 16th of October.

Dr. Bell was requested as early as possible in the season to visit the Great Manitoulin Island with a view to examine and, if found necessary, correct the topographical and geological lines that had been laid down to be engraved for publication on the sheet map No. 126, on a scale of a quarter of an inch to a mile, and which had been prepared from the surveys made some years previously and would therefore, it was considered, probably require corrections and additions before being republished. Later in the season, Dr. Bell was to explore a portion of the region lying to the south of Hudson's Bay and west of the District of Keewatin.

On this work Dr Bell reports as follows:—

"In pursuance of these instructions I left Ottawa on the 12th of June and spent a short time on Manitoulin Island, where, being favored by fine weather, I got over a good deal of ground, but it was not found necessary to make any material change in the geological lines as they had been laid down. Two days were spent at Sault Ste. Marie where I hired six voyageurs for my northern exploration. On arriving a day later at Port Arthur, these men were sent immediately with Mr. John McMillan and Mr. Alfred P. Murray, who were to act as my assistants, to Wabigoon tank, on the Canadian Pacific Railway, which was selected as our starting point. Provisions and other supplies were purchased at Port Arthur the same day and forwarded to Wabigoon tank. I had ascertained by correspondence that it would be difficult to obtain bark canoes, which are almost essential for the kind of work which lay before us. In the course of a few days, however, I succeeded in obtaining four canoes large enough for carrying my party and all the supplies we required for the whole season. Smaller canoes were afterwards obtained from time to time as required.

"Before we could start on our canoe voyage, everything had to be transported over a 'tote road' from Wabigoon tank, a distance of eight miles, to Sandy Lake. Leaving this long portage on the 6th of July the general course of our route was north-eastward, or towards Cape Henrietta-Maria on Hudson's Bay.

"From Sandy Lake I proceeded to Lonely Lake by way of Minnietakie Lake and its outlet. My route then lay through Osnaburg Lake (or Lake St. Joseph) and the upper part of the Albany River, from which I crossed the country northward to the Attawapishkat River and descended this stream to the sea. Coasting southward on the west side of James Bay, the Albany River was reached and ascended to The Forks, or junction of the Kenogamin River. Following the stream to its source we passed through Long Lake and descended the Black River to its intersection with the Canadian Pacific Railway.

"Exploratory or track surveys were made of the route followed from the time we entered Long Lake till we reached The Forks of the Albany River, with the exception of the coast of James' Bay between the mouths of the Attawapishkat and Albany rivers. In making these approximate surveys, the distances were ascertained by a boat's log or by the time occupied in traversing them at a known speed, while the bearings were taken by compass. Observations for latitude were made almost every day, and the variation of the compass was also frequently ascertained, so that I have the means of checking my positions as given by the above method. Careful sketches were always made of the shores of lakes and rivers, the positions of islands, points, &c., being checked by frequent bearings. The total length of the exploratory surveys made during the season by myself and assistants cannot be stated until the work shall have been plotted. In the course of the journey, upwards of forty photographs were taken, which show the character of the natives, the scenery and the surface geology of the country traversed.

"From the above general sketch of the route followed and of the methods employed, the following brief account of the work done will be the better understood. In passing through the eastern part of Lonely Lake, a track survey was made of our route as an addition to the approximate survey of this part of the lake made by myself in 1883; and from the head of Lonely Lake (simultaneously with the geological examination of the country) surveys of the same kind were continued as above stated. Leaving the eastern extremity of Lonely Lake, we ascended the small river which flows into it, and turning up one of its eastern branches, we reached the height of land near Osnaburgh Lake.

"In passing through Osnaburgh Lake, we explored its principal bays and then descended the Albany to the outlet of Eabamet (or Labamet) Lake, on the north side. It was here that we turned northward and followed up a chain of lakes, discharging by small rapid streams from one into another until we gained the height of land separating these waters from those of the Attawapishkat River. From the head of this chain of lakes it had been our intention to follow a small river, which was reported to flow northward into a lake on the Attawapishkat River, but not succeeding in finding it, we descended a rapid stream with many portages, which followed a north-easterly course to its junction with this river. Two days before I reached the Attawapishkat, Messrs. McMillan and Murray with two men were sent back to do other work which will be referred to further on.

"On arriving at the Attawapishkat, I left my stores and large canoe in charge of one man on an island (which I called Nolin's Island) at the junction of the rivers, and proceeded with the other men to

examine the upward course of the larger stream for some distance, previous to descending it to the sea. At about eleven miles above Nolin's Island we reached the lowermost lake of the Attawapishkat, which the Indians informed me bears the same name as the river. It lies diagonally across the course of the river, and has a length of about nine miles from south-west to north-east by four miles from south-east to north-west. Two miles above Attawapishkat Lake we entered a beautiful lake of much larger size, which having as yet no distinctive name I propose to call Lake Lansdowne, in honor of the Governor General of the Dominion. This lake proved to measure about thirteen miles from south-east to north-west by about ten miles from south-west to north-east, and it is the largest sheet of water connected with the river. It contains many large islands and is much indented with bays. The surrounding country is more or less undulating and hilly, and thus affords a pleasing contrast to the level, and monotonous character of nearly all the rest of the region explored during the season. The commencement of the upward continuation of the Attawapiskat River is found in the south-western bay of Lake Lansdowne. This part of the river is described by the Indians as being broad, having, for the most part, a sluggish current and expanding occasionally into small lakes.

"The Attawapishkat River proved to be somewhat smaller than the Albany, which is not far from the size of the Ottawa above the capital. It descends at an almost uniform rate all the way from Lake Lansdowne to the sea, a distance of several hundred miles, notwithstanding the fact that in the upper part of its course it traverses Laurentian and Huronian rocks, while the lower portion flows over unaltered flat-lying palæozoic limestones. In this distance we did not require to make a single portage and from the description of the river above the lake, it would appear to be navigable without portages almost to its source, which has probably an elevation of more than 1,000 feet above the sea. Where it flows over the limestone country it is broader and shallower than in the higher parts of its course.

"Along the upper part of the river, the banks were lower than further down, where the spring freshets fill up the bed of the stream to a height of from twenty to thirty feet, and even more, above the summer level, and the ice which comes down at these times, has swept the banks clear of all obstructions and given them an uniform appearance throughout, except where cliffs and islands of limestone occur.

"The shores and islands of Lake Lansdowne are well wooded with large spruce, tamarac, aspen and rough barked poplar, with fair sized cedar and white birch; and the same kinds of wood continue along the

banks of the river for many miles down, but the timber at a distance from the water is of smaller size. In the low, level country, not only along the lower part of this river, but on the west side of James Bay generally, the greater part of the area between the rivers appears to consist of open sphagnum plains, with some small spruce and tamarac trees, either in groves or scattered singly, while the immediate banks of the streams are well wooded. In places the better class of timber forms belts extending for some miles back from the rivers. The fossiliferous limestones of the west side of James' Bay extend for a considerable distance inland on the Attawapishkat River, but they can only be mapped when my approximate survey shall have been plotted. The sea coast between the Attawapishkat and Albany Rivers is very low and uniform in outline and without indentations. The water is so shallow that we could touch the bottom with our canoe paddles at from half-a-mile to one mile from the shore In order to pass the bouldery reefs, which extend from the shore north of the Albany, we were obliged to go so far out from the land that the tops of the trees were barely visible at the highest places.

"A careful track-survey of the Albany was made from its mouth to The Forks, which, with that of the upper part also made during this season, when plotted, will enable me to map the whole course of this river, an actual survey of the intermediate portion having been made by myself in 1870. The Albany possesses additional importance from the fact of its constituting part of the northern boundary of the province of Ontario.

"From the mouth to The Forks the river passes through a low and very level country, and it is characterized by a wide shallow bed with ice-swept banks like those of the Attawapishkat, but of somewhat greater height. On the Albany the limestones do not form conspicuous cliffs and islands as on the latter stream. The numerous large islands in the Albany form one of the features of the river between The Forks and the sea. My supposition, based on former explorations, that the Devonian limestones extend from James' Bay nearly, if not quite, to The Forks, has been confirmed by the present year's examinations.

"The Kenogami River and Long Lake are described in my Reports for 1870 and 1871, but the Black River had not been previously examined geologically. The rocks in its valley were found to consist of crystalline schists and diorites, granite, syenite and gneiss.

"Before reaching the Attawapishkat River, as already stated, Messrs. McMillan and Murray with two men were sent back to perform other duty. They were instructed to make a track-survey between Eabanut Point and Abazotikitchewan Lake on the Albany, to

the latter of which my instrumental survey of 1871 had extended. They were then to proceed to make a geological examination of Cat River from Osnaburgh Lake to Cat Lake and to return home by way of Wabigoon. On my return here I found they had accomplished the above work, with the exception of the upper third of the Cat River. By using the map laid down from micrometer survey by Mr. Thomas Fawcett, D.L.S. (for the use of which we are indebted to Surveyor-General Deville) along with the track survey made by Mr. McMillan in connection with his geological notes, a considerable addition is made to our knowledge of the distribution of the rocks in the region which he traversed."

In Part G. of this volume further details are given with illustrations.

Mr. A. P. Low, accompanied by Mr. J. M. Macoun as assistant, left Ottawa on the 10th May, and proceeded to Selkirk, to await the departure of the first boat for the mouth of the Berens River, on Lake Winnipeg. This point was reached on the 28th of May.

Here, having purchased canoes, the season's work was commenced, and a micrometer survey was carried up the Berens River to the height of land, between the waters of Lake Winnipeg and those falling direct into Hudson's Bay.

This point was reached on the 17th of June, the distance along the route surveyed being 168 miles. From its mouth, the Berens River trends a few degrees south of east for 102 miles to Family Lake. Throughout this distance its course is broken by numerous small falls, entailing many short portages.

At Family Lake the river bends sharply to the north, and the survey line runs in a slightly north of east direction to the height of land, and passes through several small lakes in that distance.

The watershed was passed by a short portage, ending at two small lakes on a small stream at the head of the middle branch of the Severn River.

Following this stream in a north-east course, and on the way passing through several little lakes surrounded by broken, rocky and barren country, the party reached Deer Lake on the 19th of June. This lake is distant 22 miles from the height of land, and is very long and narrow, with several deep bays. Here the track survey which had been made by Mr. Cochrane in 1882 ended, and, having been unable to obtain an Indian guide beyond this point, much trouble was experienced in finding and following the river running out of the lake. Descending the outlet for 176 miles, another large lake was reached, the shores of which were covered with a fair growth of timber, and the soil in the vicinity of which appeared suitable for cultivation. This is called Favorable Lake.

Following the river running out of it for 100 miles, a large lake, called Sandy Lake, was entered. The country along the river was flat, and if not too swampy, would make good farming land.

From Sandy to Severn Lake the distance is 150 miles by the river, which runs through moderately good country. Here an Indian was met who acted as guide to the Hudson's Bay Company's post on Trout Lake, distant 55 miles the intervening country being flat and swampy, with a small growth of black spruce and tamarac. Mr. Low was informed at Trout Lake that summer frosts were rare, and never damaged the crops of potatoes and roots grown there. No attempt has been made to grow grain. Leaving Trout Lake, the survey was carried down the Fawn River, the outlet of the lake, which falls into the Severn River 226 miles from the lake and sixty miles from Fort Severn, at its mouth, which was reached on the 6th of August, thus completing a line of micrometer survey from Lake Winnipeg to Hudson's Bay, 882 miles long.

From Severn, the party proceeded along the coast to York Factory. The shore between these points is very low and sandy, covered with a scant growth of grass and moss, the tree line being distant several miles from the sea.

The return journey was made from York in a small boat, by ascending the Hayes River route to Norway House, and thence down Lake Winnipeg, reaching Ottawa the 19th of October.

From Lake Winnipeg to Deer Lake the country passed through is rough and rocky, covered with a small growth of black spruce, aspen, poplar, banksian pine, tamarac and white birch.

From Deer Lake to Severn Lake the surface is much more even and the soil and timber better, the latter consisting of white, black and balsam spruce, aspen and balsam poplar, tamarac and birch, many trees exceeding eighteen inches in diameter three feet from the ground. This section of the country is fit for agricultural occupation, but great difficulty will be experienced in obtaining an outlet until a railway is built.

Between Severn and Trout Lakes, and for 100 miles down the Fawn River, the country is very flat and swampy, the timber being chiefly black spruce and tamarac of small size.

Beyond this, as far as the sea, the river cuts more deeply into the surface of the country, forming a valley, the banks of which are composed of sand and clay and vary in elevation from 50 to 200 feet. Beyond the valley the soil appears light and poor, and in many places swampy, sustaining a small growth of black spruce and poplar. The rocks met with are all Laurentian gneiss as far as Favorable Lake. Here, and along the route to Trout Lake, several bands of Huronian rocks

are seen together with the Laurentian. These bands are highly magnetic and contain large quantities of pyrite. Further details of this exploration are given in Part F. of this volume.

Mr. W. Ells, in the following preliminary report of his work in the Eastern Townships, has included a number of details, bearing specially on the asbestos industry, which it seems important should be made immediately available.

"The work of the past season embraced the further examination of that portion of the Eastern Townships lying to the east of Lake Memphremagog, and of Richmond and Arthabaska, and extending thence to the Maine boundary, with the view of completing in greater detail the S.E. quarter of the map of a part of the province of Quebec known as the map of the Eastern Townships. For the purpose of better elucidating the somewhat complicated structure of this section, over 2,000 miles of roads were carefully surveyed. The settlements of the last dozen years have opened up a large tract of country which had been almost entirely inaccessible to previous explorers, and we were thus enabled the more readily to decipher and to map the outlines of the various geological formations. In this work I was ably assisted as in former years by Mr. N. J. Giroux.

"The latter part of the season was chiefly devoted to an examination of the principal mining areas, among which, on account of their great economic importance, special attention was directed to those where asbestos mining is now carried on.

"Highly important discoveries of graptolites at two points have necessarily led to a somewhat extensive re-arrangement of the several formations in the area in question, more particularly as regards the distribution of the Silurian (Upper Silurian) rocks. Thus, by reference to the Geological Map of Canada, 1866, it will be noticed that two very extensive areas of rocks which were then regarded as of this age are depicted, the one extending northerly from the vicinity of Lake Memphremagog into the township of Ham, with a breadth of some twenty miles or more, while the second, and of still larger area, embraced the greater part of the country lying east of a line N. E. from Lennoxville and extending to the boundary of Maine. During the season of 1885, the necessity for correcting the boundaries of this system was noted, but no precise palæontological data could at that time he found which would fix the horizon of a great part of these rocks more definitely. In July last, however, while examining closely the country about Lake Memphremagog, in company with Mr. H. M. Ami, considerable areas of black slates on both sides of the lake were found to be very rich in graptolites, the exact age of which has not yet been ascertained, but which are very like those found at various points on

the south side of the St. Lawrence, at and below Quebec, and which have been determined to be of Cambro-Silurian or Ordovician Trenton-Utica age.

"As regards the distribution of the Silurian (Upper Silurian) slates and limestones, it has been found that these rocks are, for the most part, confined to limited areas and patches which have escaped denudation, and now rest unconformably upon a great series of black slates and grey sandstones of presumed Cambro-Silurian age, but in which except as above referred to no fossils have been found. These patches occur principally at Lakes Memphremagog and Massawippi, Stoke Centre and North Stoke, Lakes Aylmer and St. Francis, and the Chaudière River, between the Famine River and the village of St. George, Beauce. Fossils (corals, &c.) which range from the Niagara to the base of the Devonian are found at many points throughout these rocks. Their unconformability upon the underlying slates, is however, well defined at several observed points. The relations of the crystalline schists and other associated rocks of the mineral bearing belt have also been again carefully studied by detailed surveys, and it is hoped that the additional facts which have been obtained during the past season, will, when plotted, assist in satisfactorily establishing their true position as regards the graptolitic black slates with which they appear to be conformably associated. This work will be done during the coming winter, when the final results will be duly presented.

"The various mountain masses, such as the Owl's Head, Orford, Ham and Bull Mountains, north-west of Lake St. Francis, all apparently belong to one era, and form a disconnected chain of eruptive peaks which extend north-easterly for nearly 100 miles.* Their intrusive and eruptive character and comparatively recent age is clearly established by their action upon the black graptolitic slates which flank them and which are, in many cases, highly altered along the contact, the rock being in places changed to a true porcelain. Like these, also, they give off dykes into the surrounding slates and sandstones, with which are also intimately associated the great areas of serpentine, which have, during the last half-dozen years, come into marked prominence as being the country rock of the valuable mineral asbestos.

"The various mining industries carried on at several points are in some cases marked by a decided increase in the output. The new system of mining returns will, it is hoped, eventually furnish a great amount of valuable information, and it is highly gratifying to

* This is the belt of rocks which I have elsewhere described and mapped as the Volcanic Group, or the upper division of the so-called "Altered Quebec Group;" at the same time I stated that these rocks might be of lower palæozoic (Cambrian, or of pre-palæozoic age It includes the serpentine belt, and the serpentines are undoubtedly altered igneous rocks, probably volcanic. I cannot concur in the view above expressed that these igneous rocks are comparatively recent. They are certainly older than the Levis formation. while the black graptolitic slates on the south-eastern side of them are certainly newer.—A. R. C. S.

find, in all cases, such a willingness on the part of mining men to assist in every way the collection of mineral statistics.

"The principal mining industries at present carried on in the section embraced in the season's work are:—

"The slate quarries of Rockland and Danville—the latter lately re-opened—while the former, by marked improvement in plant, is also rapidly increasing its output.

"The copper mines of Capelton, also showing a marked increase in output.

"The asbestos or crysotile mines of Thetford, Coleraine and Wolfestown, and the gold mines of Ditton and the Chaudière.

"As regards the latter industry, it is to be regretted that no returns can, apparently, be procured as to the quantity of gold annually obtained from the Ditton gold field. The area being entirely in private hands, over which the local Government has no control, no royalties are paid, and no definite data can be had. There is no doubt, however, that a very large quantity of gold has been found in this section and that the prospects for profitable workings are excellent.

"In the Beauce district, work is being carried on in the Cumberland stream, a branch of the Famine, by Captain Richards; and on the St. André, near St. George, by the St. Onge Company. The returns from the former are very encouraging, but at the latter, considerable difficulty has been found in reaching the gravels of the old river channel, though gold is taken out in small quantity.

"The mining of asbestos is carried on at several points along the line of the Quebec Central railway, viz., at Thetford, Black Lake, Coleraine and Belmina. Some work has also been done near Coleraine station. Near Danville, four miles from the Grand Trunk railway, a mine of considerable extent has been operated for several years. As this industry has already grown to large proportions, and bids fair to become one of the most important in the Dominion, a brief description of the various asbestos properties, its mode of occurrence, and some facts bearing on the future of the industry may be of general interest.

"The various companies engaged in mining asbestos at Thetford are King Bros., the Boston Asbestos Packing Co., Johnston & Co., and Ward Bros.; while at Black Lake and Coleraine are situated the mines of the Anglo-Canadian Co., Frechette's, and the Lionais Martin or Scottish Canadian Company's property. These all lie along or near the line of the Quebec Central railway, which crosses the property at Thetford, while at Black Lake it is from a quarter to half a mile distant from the workings. At Belmina, which is about four miles from the railway at Coleraine station, a small force of men, from six to eight, have been engaged for several years merely on explo-

ratory work, on property owned by Mr. John Bell, of London, England. With a view of acquiring more definite information concerning this valuable mineral, a somewhat detailed examination of all these properties was made, in order to give advice and information, if required, to any persons interested in this industry.

"All the asbestos mines in the Eastern Townships are situated on portions of the great serpentine belts which extend in tolerably direct lines, though with many breaks, north-eastward from the Vermont boundary for some distance beyond the Chaudière River. Further east, these peculiar rocks present large areas in the Shickshock Mountain Range, which extends through the northern portion of the Gaspé Peninsula in rear of Ste. Anne des Monts, and further east on the lower part of the Darmouth River. Though indications of asbestos are found at most points throughout the whole serpentine formation, the developments of it appear, in so far as yet known, to be greatest in the areas about Thetford and Black Lake and near Danville, though there is no apparent reason why it should not be found in paying quantity at other points, and it is possible that subsequent exploration will largely extend the area where profitable mining operations can be carried on.

"The serpentines, without going into any detailed account of their mode of formation, may be stated to be intimately associated with masses of dioritic or doleritic rocks, of certain varieties of which, rich in olivine or some allied mineral, the serpentine is in many cases doubtless an alteration product. The serpentines are also frequently associated with masses and dykes of whitish rocks, often composed entirely of quartz and felspar, but at times with an admixture of black mica, forming a granitoid rock. They occur generally not far from the axes of certain anticlinals which exist in the group of rocks designated the altered Quebec Group by Logan. (See foot note ante.) The asbestos (crysotile) traverses the serpentine in veins often irregular, and ranging from mere threads to a thickness of three and even in some cases six inches, in all of which the fibre of the vein is, unless affected by the dislocation of the containing rock, at right angles to the sides of the fissure. The rock is in many cases somewhat impure, from the admixture of grains or small irregular veins of chromic iron, which break the continuity of the fibre in the vein and require the mineral to be carefully "cobbed" in order to separate these impurities. The veins at or near the surface are also affected by the infiltration of water by which the asbestos is discolored and its value correspondingly reduced. This is especially noticeable in areas where the surface serpentine is shattered, either by the action of weather or other causes, and this discoloring ceases as the rock be-

comes solid. As a rule, the veins increase in value or quality of fibre as lower depths are reached. The veins are not, however, continuous. They frequently vary in size, and like all mineral veins, they are affected by faults or slides which often cut off, completely, a valuable working face. In such cases the slicken-sided character is very marked; sheets of impure or imperfect asbestos with long coarse woody fibre lying along the lines of fault. The veins have often the aspect of true segregation veins, and the containing walls often change their character for a distance of half an inch to three inches on each side of the vein. The theory of their formation is, however, as yet an open question.

"Asbestos mining was commenced at Thetford in the year 1878, by what is now known as the Boston Asbestos Packing Company. The demand at that time was exceedingly limited and considerable difficulty was at first experienced in finding a market. The output for that year did not exceed 50 tons, but its value was soon ascertained, and explorations on the serpentine belt at this place resulted in finding asbestos in workable quantity over a considerable area.

"The Thetford River appears to mark the western limit of the serpentine on these properties, the rocks on the other side of the stream being altered slate and sandstones. To the east of the railway which cuts directly across the area, the serpentine forms a knoll with an elevation of about 90 to 100 feet above the track. All the works are confined to this portion of the area and consist of open cuts in the face of the hills, nothing apparently having yet been done to ascertain the value of the area between the railway and the river.

"The quality of the asbestos at all the four mines at this place may be stated as excellent. The fibre is fine and readily worked, and the veins are, for the most part, especially in the lower cuts, comparatively free from chromic iron or other impurities, reaching a width of from three-quarters of an inch to four inches, though in some, notably the quarry of Johnston & Co., veins of five or six inches are observed. The fibre in these large veins is not, however, of such good quality, in so far as yet worked, as that found in those of less size, and veins of an inch and a half to three inches give as good material as can be wished. Numbers of such veins, yielding fibre which ranks as extra first quality are found in all the mines at this place. In some of the cuts these appear as a perfect interlacing network in the surrounding walls, and can be counted by the dozen. While all these properties may be said to be about equally productive, that of the Boston Company may be especially mentioned, both for the quantity of its output, which will probably equal that of the three others combined, as well as for the excellent way in which the property has been developed with a view

to successful future operations, by its experienced manager, Mr. Thomas Sheridan, and also as illustrating the remarkable improvement in the quality and increase in the quantity of the fibre as the depth increases; a feature clearly established at all the mines, not only in this vicinity, but also at Black Lake.

"The profitable mining of asbestos is at present, apparently, only limited by the demand. The quantity extracted since the commencement of operations here may be briefly stated thus;—

"Boston Asbestos Packing Company, opened 1878, output for 1886, 700 tons. Total output to end of 1886, 30,000 tons.

"King Bros., adjoining to north, for 1886, say 250 tons, total since 1881, 850 tons.

"Irving-Johnson Company for 1886, say 400 tons, opened since 1879, total 2,500 tons.

"Ross-Ward Bros., one quarry, three years only, say 400 tons.

"The cost of extraction varies in different localities and depends upon how much barren rock is encountered, which owing to the action of faults is greater in some cuts than others. It may, however, be safely put down at $20 to $25 per ton.

"The prices obtained for the asbestos at points of shipment on railways range from $50 to $55 per ton for second quality to $80 or even $100 for first, a considerable portion of that taken from the lower cuts realizing the latter figures. The markets are Great Britain, Germany, Belgium, the United States and Italy.

"The majority of the veins worked range from three-fourths of an inch to two inches and a half. The material is blasted out, carried to the dump, broken up and cobbed by boys and old men, who grade the asbestos, according to the color as well as the purity of the fibre, with due regard to its length. The wages paid for laborers in the quarry range from $1 to $1.10 per day, and for boys and cobbers, 50 cents.

"The comparison of the cost of extraction with the value of the raw material shows a very good margin for profit. The works at this place are, however, carried on, for the most part, during the six months of summer and autumn only, since it has not yet been found advantageous, in view of the limited market, to undergo the inconvenience and extra expense of continuing operations during the winter. As the market enlarges, however, the mode of working will doubtless adjust itself to the demand. The properties worked at Black Lake are situated on the west side of a steep ridge of serpentine which rises to a height of about 900 feet above the waters of the lake itself. The three areas are contiguous and from a quarter to half a mile east of the railway. The work is carried on by open cuts in the face of the hill, in all of which veins of excellent asbestos are disclosed, ranging in size

up to four inches. The fibre is, in most of these, somewhat discôlored from the presence of water which penetrates the shattered serpentine, and, as a consequence, the greater portion of the output grades as second; but in most of the openings, the solid rock is now reached, and the quality of the asbestos is rapidly improving. These mines have not been in operation so long a time as those of Thetford, but the output, which is as follows, shows readily the growing importance of this locality:

"The output of the Anglo-Canadian (formerly Hopper's mine) for 1886 may be stated at 550 tons, and total output for the four years, 1,500 tons.

"The Frechette mine has been at work only one year, with an output of about 200 tons.

"The Lionais-Martin mine, now the Scottish Canadian Company, has done a large amount of exploratory work. Its estimated output for 1886 may be stated at 250 tons, with a total from the commencement of, say 700 tons.

"The cost of mining here varies but little from that at Thetford, and may be stated as averaging $25 per ton.

"In the vicinity of Black Lake, several other areas occur, in which the exploratory work done, though not very extensive, shows indications that fully warrant the statement that a valuable and profitable output may be expected. These properties are known as the Reed and Hayden properties, and are situated on lots 27 and 28, range B, Coleraine. In various open cuts in the sides of the hills, numerous veins are disclosed, ranging upwards to a width of two inches and a half, with surface indications apparently in no way inferior to those of the adjoining properties now being worked at this place, or even on those at Thetford, not only as to number and size of veins, but also as to quality of fibre. These indications appear at many points on both the Hayden and Reed properties, which embrace an area of 200 acres Between these and Cariboo Lake, the serpentines extend as an apparently continuous ridge, and show at intervals very good indications of asbestos, but this portion has not as yet been explored to any extent, and but little can be said from actual examination of the value of this section of the serpentine belt, though that it will be found equally productive with adjoining areas seems reasonable.

"In the vicinity of Coleraine station serpentine also occurs, but the main ridge, extending south-west from Black Lake, keeps to the north-west about one mile and a half, where it forms a conspicuous hill feature. This has been but little examined, but an opening was made on its south-east extremity during the present year by Mr. Kennedy, disclosing the presence of a number of veins of asbestos, one of which

was, near the surface, nearly four inches thick. Sufficient work was not done to determine the persistence and value of these veins. An interesting feature in connection with this opening is the presence of mica in considerable quantity in direct contact with the asbestos, a feature not as yet noted at any other point.

"The asbestos area of Wolfestown is situated on the north-east extremity of a serpentine ridge, which extends south-westerly, with several interruptions, from the road leading from Coleraine station to Wolfestown, to the vicinity of Lake Nicolet. It is owned by Mr. John Bell, of London, Eng., and though a considerable sum of money has evidently been spent on this property, it has been largely on explorations. The surface indications, while not equal to those of Black Lake, yet show at several points numbers of veins, some of which reach a thickness of an inch and a half and even two inches. Only a small force of men is employed, and the property cannot yet be said to be fairly proved. Considerable deposits of chrome iron are found in the hills on this area, which embraces 600 acres. At present it would be exceedingly difficult to give any decided opinion as to the merits of this property. A very fair showing of workable veins has been exposed in the upper part of a deep cut which it is now proposed to intersect at a considerably lower level. Should the same rule of increase which holds at Black Lake and Thetford apply here, there should be good paying ground when the lower level is driven in past the capping of barren rock, provided the veins already disclosed are not cut off by faults, whose presence is noted here as at other points. The total amount of asbestos taken from the Belmina area is about twenty-five tons.

"In addition to the properties already described, the only other point where this mineral is worked successfully is on lot 9, range 3, Shipton, about four miles from Danville on the Grand Trunk Railway. The outcrop of the serpentine here is quite limited, with steep sides all round, and contains a number of veins of asbestos, mostly of small size, though the quality of the fibre is good. Faults have affected the value of this property considerably, some very good veins with a thickness reaching two inches having been cut off completely at a depth of 50 feet from the surface. The output, however, is considerable, being 455 tons, for the year ending 28th August, 1886, but from various causes it is at present much less, the mine not being worked to its full capacity.

"It will be seen from the facts here presented that the asbestos interests of the province are very important, and, judging by the rate of increase in production for the last six years, it will soon assume large proportions. The demand is annually increasing, as new uses for the

raw material are being found, and from the prospects presented not only at the mines already opened, but in those areas contiguous which appear equally rich, the supply is practically limitless.

"During the past year attention was directed to the deposit of marble situated near Marbleton, in the township of Dudswell. This was described by the late Sir Wm. Logan in the Geology of Canada, 1863, p. 827. A great variety of marble is here presented, some of which are very fine, notably a black ground, with veins of ochre yellow. Though the deposits of marble in the vicinity have been extensively used for some years for the manufacture of lime, the desirability of utilizing the finer grades as marble was such that a company was formed during the past year for this purpose. The ground has been cleared and a channelling machine set to work. The area of the present quarry is about forty feet square. The black and gold variety is interbedded with others of dove-grey and variegated shades, all of which present a fine appearance when polished, some bands entirely composed of fossils (corals) notably so. The rock bids fair to be sufficiently solid to extract valuable blocks of large size in the second cut, and it is the intention of the company to erect, in that case, sawing and polishing machinery for its manufacture.

The work of the season began on the 17th of May, and extended to the 1st of November.

At the end of July Mr. H. M. Ami was instructed to join Mr. Ells in the Eastern Townships for the purpose of assisting him in collecting fossils and in examining the various fossiliferous localities which had been discovered, with the view of fixing the age of parts of the rock series of the district. Messrs. Ami and Ells together obtained about five hundred specimens from various places near Lake Memphremagog, in Stukely, Stoke and Dudswell; along the Chaudière River, at Quebec City, and at Montmorency and the Island of Orleans.

Rev. Professor J. A. K. Laflamme having consented to continue the work previously carried on by him in connection with the accurate definition of the boundary of the Lower Palæozoic rocks on the Archæan to the north of the St. Lawrence, and of the areas respectively occupied by the various sub-divisions of the Cambro-Silurian, sketches the result of his labors as follows:—

"I have traced on the map, with as much precision as possible, the limits of the Laurentian and of the Palæozoic rocks between Quebec and Three Rivers, as well as the several divisions of the Cambro-Silurian which are found in this part of the country. I have, however, unfortunately, been unable to complete the stratigraphical study of the region immediately surrounding the city of Quebec.

"The geological map received from Ottawa for use as a basis of

work was found exact in its principal lines. Some slight errors which I have noted have been carefully corrected, and will be indicated on the map which will be submitted with my report.

"Certain facts which appear worthy to be remarked are as follows:

"(1.) The discovery of some small deposits of apatite in the Canton de Caxton merit special attention, as it is not impossible that more important deposits will be found in the future, as the Laurentian gneiss of the neighborhood is traversed in different directions by veins of crystalline calcite, rich in mica and pyroxene.

"(2.) The great thickness and quantity of sand which occurs on the banks of the St. Maurice renders the observation of the exact limits of the different geological formations impossible, particularly as regards the boundary between the Utica and the Trenton limestone. The sand contains a great quantity of ferruginous matter, giving rise to abundant deposits of limonite wherever the surface is occupied by swamp. Thus in this part of the country we find the most ancient iron furnaces of Canada, several of which are now, however, not in operation, owing to the scarcity of fuel.

"(3.) The Utica shales preserve there one of their distinctive characters in giving rise to strong and highly saline mineral springs, the therapeutic value of which has long been known.

"(4.) The same shales with the subjacent Trenton limestones produce considerable quantities of light carburetted hydrogen, almost pure, and capable of being utilized at several places very profitably. One in particular of these flows of combustible gas occurs quite close to the old forges, abandoned on account of the scarcity of fuel, and there, it appears, all the conditions exist which would justify boring operations with the object of augmenting the flow of gas, for the purpose of resuming the smelting opérations. The boring made at St. Grégoire leads to the belief that the gas is stored principally in the Utica shales. If this be the case, it would be necessary only to sink wells through the thick bed of clays which cover this formation here, to produce an abundant flow of gas.

"(5.) The Trenton limestones have a great development at St. Alban, where are found the well known quarries which yield the best building stone of the province of Quebec. The limestone is crystalline and fossiliferous. The quarries yield annually from four to six thousand toises of stone.

"(6.) The study which I have made of the immediate vicinity of Quebec, though superficial, leads me to the belief that there are on the northern side of the rock mass of this vicinity tongues of Utica shale. These would be somewhat analogous stratigraphically to those shown by Sir W. E. Logan's section of the Island of Orleans. It appears to

me impossible to class as Trenton the whole of the exposures comprised between the left bank of the river and the heights of Beauport, Charlesbourg and Lorette.* There is quite close to the edge of the Laurentian a band of variable width of Trenton limestone, but the remaining space is occupied by shales very like those which are again found to the south-east of the Montmorency Fall, between the fall and the river."

New Brunswick.

Prof. L. W. Bailey was again occupied during the summer in the geological survey of New Brunswick, with the object in view of completing the sheets of the geological map yet remaining unfinished. Prof. Bailey was personally assisted during the season by Mr. J. W. Bailey. His preliminary account of the work, with that of Mr. W. McInnes in the same province, is given below.

"In accordance with instructions, my own attention was directed chiefly to the study of the Silurian system of northern New Brunswick with a view to the determination of the succession of its rocks and their relations to the formations above and below it. With this object in view, examinations begun in the previous year on the northern side of the Silurian basin, where it comes into contact with the rocks, supposed to be of the age of the Quebec Group, in the vicinity of Lake Temiscouata, were renewed and extended both easterly and westerly, while an examination was also made of the neighboring portions of Aroostook county, Maine, where the same Silurian rocks are associated with others which have been supposed to be Devonian. The result of these examinations was to show a general parallelism between the succession of rocks as seen on Lake Temiscouata, on the northern side of the Silurian tract, with that previously made out on its southern side, on the Beccaguimic River, in Carleton; while portions of the rocks of Aroostook county, previously regarded as Devonian, would seem also to occupy a position in the Silurian system. The final determination of these points, however, is largely dependent upon the examination of their contained fossils. Of these, somewhat numerous collections were made on Lake Témiscouata, on the Tuladi and Squatook rivers, at Squaw Lake, Maine, and at Ashland, and along the course of the Aroostook River in the same state. These are now in the hands of Mr. Whiteaves for determination.

* This is quite true, but there seems no great difficulty in considering them to represent the Trenton group, *i. e.*, the Chazy, the Birds-eye, Black River, Trenton, Utica and Hudson River formations. In any case, the fossils of the Citadel Hill rocks ally them more closely to the Trenton group than to the Levis, the graptolitic fauna of which belong to a much older horizon. The main point now to be decided is whether the Citadel Hill rocks are below or above the Black River limestone formation.—A. R. C. Selwyn.

"The work in the Témiscouata region has already sufficed to show, irrespective of fossils, that a considerable area about the lake of that name, regarded by Sir W. E. Logan as of the age of the Quebec Group, is at least as recent as Silurian, while other areas to the north, referred by Mr. Richardson to the Silurian, really belong to the more ancient Cambro-Silurian system. A complete exploration of the region intervening between the Têmiscouata Portage Road and Lake Metapedia on one side, and between the same road and the Chaudière district on the other, is required before the real structure of this region can be fully understood.

"The essential object of the work carried on by Mr. McInnes was the completion of the information necessary for sheets No. 2 south-west, and 2 north-west of the geological map of New Brunswick, on this work Mr. McInnes reports as follows:—

"I left Ottawa on the 3rd of June and arrived at Fredericton on the 9th, spending three days, in passing, in a brief examination, in company with Mr. Ells, of the region about Lake Témiscouata. After a week in Fredericton, occupied in making tracings of Crown Land plans and in completing arrangements for the season's work, I started for the Upper St. John district on the 14th of June. Arriving at Andover, advantage was taken of the high water prevailing in the streams to make a survey by micrometer telescope of the right hand branch of Tobique River, of Campbell River, and of Trousers, Long, and Serpentine lakes; in descending the Serpentine, a sketch survey of that stream was also made. The country passed through on this exploration lies mostly within the pre-Cambrian and the granite areas; the latter extends from Little South-West Miramichi Lake across to a point about midway between the outlet and inlet of Long Lake, and the former occupies most of the district between the granite and the main Silurian area.

"The region in general is very rough and broken with high hills and ridges, and the surface is often thickly strewn with large blocks and boulders of the underlying hard crystalline rock. The forest growth is chiefly black spruce and fir, mixed with cedar along the watercourses, and with scattered pine, birch, mountain ash, &c. What is probably the first representative yet noticed in New Brunswick of the Oriskany sandstone, so common in the neighboring state of Maine, occurs near the confluence of the Don and Campbell rivers. A broad band, three miles or thereabouts in width, of buff weathering dolomitic sandstone, with fossiliferous layers, crosses the river at this point. This seems to be an isolated patch lying upon the older rocks which has escaped the general denudation.

"In the latter part of July, two weeks were spent in making odometer surveys of the roads between Edmundston and St. Francis, in Madawaska county, and between Edmundston and Notre Dame du Lac, Témiscouata, chiefly for the purpose of topographical detail. During August a micrometer survey was also made of Lake Témiscouata, and a sketch survey of Horton Branch of Tuladi River.

"The remainder of the season, September and part of October, was spent in exploring the region lying between the Tobique and Campbell rivers, by ascending the stream flowing into the Tobique from the south, and by a paced survey of the portage road to Trousers Lake. This whole area is very hilly and rough, and presents a marked contrast to the rest of the valley of the Tobique below the forks, where the soft and calcareous character of the Silurian and Lower Carboniferous strata has produced a soil of great fertility, with numerous fine alluvial flats and islands which, when cleared of the large elms and balsam poplars with which they are generally wooded, form nice meadow lands. Extensive beds of gypsum, which occur near the summit of the Lower Carboniferous outlier, add to the value of the lands.

"Collections of fossils were made from the Silurian beds on Campbell River and Riley Brook, which are in the hands of the palæontologist of the survey for identification.

"Leaving Fredericton on the 20th October, after a few days spent there in packing and labelling specimens, &c., I arrived in Ottawa on the 22nd, and resumed work in the office.

"During the summer, about 200 miles of lakes and streams were surveyed with the Rochon micrometer telescope, 100 miles of roads with the odometer, and about 70 miles of rough roads and streams by pacing and sketch surveys."

The joint report of Messrs. Bailey and McInnes on the work above referred to is Part N of this volume.

Mr. R. Chalmers left Ottawa on the 1st June, with instructions to work out in detail the surface geology of the districts comprised within the two quarter sheet maps, 2 N.E. and 6 S.W., New Brunswick. Mr. Chalmers' preliminary statement with regard to the work carried out is as follows:—

"Certain sections included in sheets 3 S.E. and 3 S.W., the surface geology of which was investigated during the previous summer, had first to be further examined to obtain additional data to complete these maps, and accordingly a part of June was devoted to this object. On finishing this I started on a canoe trip to explore Shippegan and Miscou Islands and the adjacent mainland, and then ascended the Nepisiquit River to the limit of the map. Thence I crossed over to the North-West Miramichi River, and examined the intervening coun-

try as well as portions of that lying north of the Nepisiquit as far as time would permit. The general elevation and topographic features of this interior region were noted, and some points of interest relative to the peculiar character of the Nepisiquit as a drainage channel, observed. Immediately thereafter I went up the North-West Miramichi from Newcastle, and on the return trip ascended its affluent, the Little South-West, some distance. Interesting observations on the country drained by these rivers, and on the terraces and intervales skirting them, were made. Subsequently, another canoe trip was made down the Miramichi Bay, and the coasts and islands examined as far as Portage Island and Escuminac Point. These explorations occupied my time till about the middle of September. The remainder of the season was devoted to the study of the character and distribution of the deposits in those sections lying at a distance from the coasts and rivers and in mapping the forest-covered areas. All back settlements and places accessible by roads of any kind were visited. The old Indian camping-grounds at Tabusintac and Derby were also explored and some relics found.

"The investigations of the season have resulted in showing a much wider extension of pre-glacial gravels and sands than was hitherto supposed to exist in New Brunswick. From the evidence afforded in numerous sections in different parts of the area under discussion, it would seem that they must have formed a general covering of some thickness, especially upon the flat Carboniferous plain, and probably mantled the crystalline rocks of the interior as well, although the proofs of this are not so abundant. These gravels were no doubt considerably reduced in bulk previous to the advent of the ice age, by atmospheric erosion, especially on the latter tract, or wherever the country was hilly or had an uneven surface, and along the lines of drainage. Near the coast large areas are still covered by them, however, but overlain by stratified materials. Either the ice of the glacial period has passed very lightly over the tract, or it has never been glaciated, and was probably submerged during the greatest extension of the ice.

"Some interesting facts were observed regarding boulder distribution. Blocks of granite, felsite, gneiss, diorite, &c., are abundantly strewn over the whole area examined. These together with the courses of striæ show that the general ice movement, as stated in my preliminary report, Annual Report, 1885, page 5GG, was eastward or north-eastward from the higher grounds of the interior. Besides this, however, other and probably smaller local glaciers followed the valleys in different directions. The boulders of crystalline rocks met with below the 200 feet contour line do not now occupy the sites to which

they were borne by glacier ice, but appear to have been shifted about by floating ice since on the shores of the receding post-Tertiary sea, as they are found almost wholly on the surface.

"Within the Miramichi basin no maritime terraces were found at a greater height than 150 to 160 feet above sea level, and it therefore seems proboble that the post-Tertiary subsidence was hardly as great there as in the Baie des Chaleurs district.

"Regarding river terraces, a number of facts were collected which serve to throw light on their origin and on the relation they bear to the rivers which formed them. The Little South-West Miramichi, the most rapid river in north-eastern New Brunswick, has the highest and finest terraces.

"Close attention was given to the agricultural character of the country examined. Large intervales and considerable tracts of good uplands were seen along the Miramichi River.

"Observations were also made regarding the forest growth. The approximate limits of the burnt forest areas, particularly that of the great Miramichi fire of 1825 was located, and the extent of country cleared and inhabited was likewise noted.

"Extensive beds of peat were observed at Point Escuminac, Tabusintac, Miscou Island and elsewhere near the coast. The bottoms of these seem now to be slightly below high tide level, and their thickness in some places is known to be upwards of 20 feet. They apparently owe their growth to proximity to the sea, where the conditions of temperature, moisture, &c., are favorable. Sand beaches, drift wood, and in one instance a charred log, were found at the bottom of these peat deposits.

"Beaches of blown sand are characteristic features of the coast along the Straits of Northumberland. They appear to have been produced by the action of the sea along a shallow, stationary coast margin. Under some of these, rock, *in situ*, was seen nearly as high as sea level. A singular beach formation is now being thrown up at the north-east point of Miscou Island, in which bones of the walrus were found.

"The field work was brought to a conclusion on the 11th of November."

Mr. Chalmers' full report, with the quarter sheet maps 3 S.E. and 3 S.W., is Part M of this volume.

Nova Scotia.

Mr. H. Fletcher and assistants were engaged during the season in continuing and extending the geological work carried on by them in Nova Scotia in previous years. It was found advantageous to detach

Mr. Faribault for the investigation of a separate district. The following summary of the work of both parties is presented by Mr. Fletcher, that portion of it referring to Mr. Faribault's exploration having been supplied by him :—

"Surveys were made during the summer of 1886 to the westward of the district referred to in the Summary Report for 1885, page 20, so that a geological map can now be constructed of all that portion of Nova Scotia lying east of longitude 62° 30′, including the whole of Antigonish and Guysborough counties and part of Pictou and Halifax counties.

"Mr. Faribault was again put in charge of the work among the gold-bearing rocks of the Atlantic coast. Mr. Robert assisted me in Antigonish and Pictou counties, and was for a long time engaged in mapping the plications of the Lower Carboniferous rocks and studying their relation to the metamorphic rocks of the hill ranges.

"The general distribution of the Carboniferous rocks over most of this area was described in the above mentioned Summary Report. Many additional details of structure have, however, been obtained, and the various basins into which the different sub-divisions can be separated have been carefully traced. The Carboniferous limestone runs in a narrow belt along the eastern shore from Antigonish to Morristown, and a patch of this formation occurs also at the mineral spring in Hallowell Grant; but the greater part of the Carboniferous rocks between Antigonish and Cape George, including the so-called coal mines of Malignant Brook, Hallowell Grant, and other places in the neighborhood, belongs to the "Metamorphic Carboniferous," Horton or Basal conglomerate group. Underlying the Lower Carboniferous at McAra's Brook, is a small area of red and greenish slates and sandstones, apparently Upper Devonian:, from which Mr. Weston obtained certain tracks and fossil plants. Beneath these lie the Silurian rocks of the well known Arisaig shore, running in a narrow belt eastward to McNeil's Brook, and underlaid by Cambro-Silurian and perhaps older rocks. In addition to this Silurian area, several others were found in the region in question. (1) Two small patches on the sea shore at Cape George; (2) a small patch west of Vamey's Brook; (3) a long narrow basin in the deep picturesque valley along the railway from James' River to the west end of Marshy Hope; (4) a broader belt extending from Bailey's Brook to Avondale, thence up Barney's River to Kenzieville, thence along the telegraph road to Glenshee, thence to the St. Mary's road at McPherson's mills to join the area of pre-Carboniferous rocks, shown on Sir Wm. E. Logan's and Hartley's map of the Pictou coal field, a large part of which, however, belongs to the underlying Cambro-Silurian; (5.) a small patch at Moose River; (6)

the broken basins north of the East River of Pictou, extending from the vicinity of Beaver Lake down stream towards Springville, and described by Sir J. W. Dawson in Acadian Geology, and by Dr. Honeyman in the Transactions of the Nova Scotian Institute of Natural Science.

"But by far the greater part of the districts underlain by pre-Carboniferous rocks is occupied by rocks older than Silurian (those containing the iron ore at Londonderry mines, probably Cambro-Silurian), and by a series of felsitic, mica, hornblende, chlorite, talc and other schists resembling those in the Cobequid Hills called Archæan by Mr. Ells, but which have not yet been examined with sufficient care in Antigonish and Pictou counties to determine that they are not a part of the Cambro-Silurian series. On the sea shore at Arisaig and Georgeville are exposures of very crystalline limestone and other rocks, which have also been referred to the Archæan, but of which no more can be at present affirmed than that they form pebbles in certain conglomerates, which are apparently Cambro-Silurian.

"In the Cambro-Silurian strata only a few obscure fossils were found at McNeil's Brook, where also, as well as in the Malignant and Doctor's Brooks, deposits of red hæmatite, probably of great thickness and value, have been exposed in many places; but the want of a convenient shipping place has hindered the development of these ores. Iron has also been found in Barney's River, French River and other places. Small quantities of the precious metals are reported to have been found in the numerous quartz veins of the Cambro-Silurian rocks at Vamey's Brook, Bailey's Brook, Rights River, Malignant Brook, Georgeville and other places; but nothing to warrant the belief that they exist in paying quantity was seen by us.

"In addition to the coal found in the Lower Carboniferous, as stated above, it has been sought, of course in vain, in the black Silurian slates of Arisaig, Kerrowgare and other places.

"Traces of copper and lead have been found in all of the formations above described, as at Arisaig, Moose River, Blue Mountain, and other places, but apparently not of economic importance. Innumerable veins, usually of white quartz, cut the Cambro-Silurian rocks as at Sutherland River, but seem to be invariably barren.

"Mr. Faribault was assisted during the season by Mr. M. H. McLeod, and part of the summer by Messrs. A. Cameron, G. B. Faribault, and A. H. McLeod.

"The first four months were spent in making a detailed topographical and geological survey of the country lying between the Liscomb and Sheet Harbor rivers and the Atlantic coast. The country examined consists entirely of the gold-bearing rocks (Lower Cambrian ?)

which are much less altered than those seen last year in the vicinity of the granite dykes south of West River, St. Mary's. No fossils, however, could be found in them. Some seven miles up Ecum Secum River, many Silurian fossils were discovered in the drift, but whether they were carried from Antigonish county or belong to an isolated patch of Silurian in the gold-bearing rocks, could not be ascertained. Much attention was paid to the stratigraphy of these latter rocks with the view of ascertaining the position of possible new gold districts.

"The only gold mine now being worked in the region surveyed is the well-known Salmon River mine, where much work is still being done with very good returns. The following gold mines, not worked at present, were also examined:—Hattie's mine, quarter of a mile east of that at Salmon River, Harrigan Cove mine, Moose Head mine and Ecum Secum mine. Besides the quartz leads which have been prospected at various places and are known to contain gold, many quartz veins of very good appearance were also seen at the head of Moser's River.

"Over a month was employed in the latter part of the season in revisiting the country previously surveyed along the south shore from Liscomb River to Cape Canso, in order to obtain more definite information relating to the general structure of the gold-bearing rocks, the map and report of which will be ready for publication next spring. A large number of rock specimens, illustrating the alteration of the various strata as they come near the granite, was collected. Five hundred and thirty-eight miles of stream and 130 miles of road were measured by Mr. Faribault, and many heights taken with the barometer.

"Field work was begun on the 2nd of June and continued till about the end of November."

The detailed report of this work is now presented in Part P of this volume.

PALÆONTOLOGY AND ZOOLOGY.

Under these headings, Mr. Whiteaves reports that the systematic catalogue of the zoological specimens contributed by the Department of Fisheries to the Colonial and Indian Exhibition, of which mention was made in last year's report, has been revised and published in the shape of an octavo pamphlet of 42 pages, 1000 copies of which have been distributed in London.

The study of by far the larger portion of the extensive series of recent marine invertebrata dredged or otherwise collected by Dr. G. M. Dawson and Mr. D. B. Dowling, in 1875, in the Strait of Georgia,

Discovery Passage, Johnstone Strait and Queen Charlotte and Quatsino Sounds, as well as that of the whole of the marine fishes, birds and other vertebrates from the same region, has been completed, and a paper upon them, which is now in the printer's hands, has been read before the Royal Society of Canada at its last meeting. All the species of Foraminifera, Anthozoa, Echinodermata, Brachiopoda, Mollusca, Ophidians, Batrachians, birds and mammals, have been determined and labelled, and the duplicates made up into sets for distribution, as far as the time would permit. The Crustacea obtained in these dredgings have been sent to Professor Sidney J. Smith, of Yale College, and the hydroids and polyzoa to the Rev. Professor Hincks, of Leigh Woods, near Bristol, England, who have kindly promised to report upon them.

A paper entitled "Illustrations of the Fossil Fishes of the Devonian Rocks of Canada," which is also now in the press, has been prepared and read at the last meeting of the Royal Society of Canada. This paper, which is illustrated by quarto plates, contains fuller descriptions than have yet been published of four out of the eight remarkable species discovered in 1880 and 1881 in the Upper Devonian rocks at Scaumenac Bay, Que., and the homologies of the Canadian *Pterichthys* or *Bothriolepis* are discussed at some length.

A considerable portion of the letter-press of Part II of the first volume of the "Contributions to Canadian Palæontology" has been written, and the lithographic plates required to illustrate it have been prepared. This report, which it is hoped will be issued early in the spring of 1887, will contain descriptions of the fossils, and more especially of the crinoids and blastoids, of the Hamilton Formation of Western Ontario.

A preliminary examination has been made of the large and interesting collections of Palæozoic and Mesozoic fossils made this year by Mr. R. G. McConnell in the Rocky Mountains, and of the Cambro-Silurian or Silurian fossils collected by Mr. A. P. Low on the Fawn branch of the Severn River.

The skeleton of the Harp Seal obtained by Mr. T. C. Weston in 1861, from the Post-Pliocene clays of Montreal, and that of the White Whale or Beluga (*Delphinapterus catodon*) found in deposits of similar age at Cornwall, Ont., in 1870, have been skilfully articulated by Mons. Jules F. D. Bailly, and now form conspicuous objects in the upper flat of the Museum.

Sixteen additional specimens of mammalia, six of which are seals, and thirty of birds, have been mounted and placed on exhibition during the year, and the number would have been greater but for the fact that Mr. Herring's time up to the first of April was occupied in clean-

ing and remounting a large number of specimens of birds, &c., which were sent to the Colonial and Indian Exhibition. All the species added to the Museum during the year in the department of zoology, a list of which will be found on pages 48-54 A, have been examined and determined, and the whole series of mammals and birds now in the cases has been re-labelled and re-arranged. Some progress also has been made in the labelling and classification of the numerous specimens of fossils and recent invertebrates that have also been lately added to the Museum.

The number of letters written is 270, many of which partake of the nature of "reports."

Most of Mr. T. C. Weston's time has been spent in museum work, in the classification and arrangement of the Carboniferous, Cretaceous and Laramie fossils, in conjunction with Mr. Ami, in labelling and planning the arrangement of specimens of gold, *Eozoon*, &c., selected for transmission to the Colonial and Indian Exhibition, and in field exploration.

During the months of July, August and September, he made large collections of fossils and lithological specimens from the Carboniferous, Devonian and Silurian rocks of Nova Scotia and Cape Breton. A list of these fossils, with other information, will be embodied in a forthcoming report* by Mr. Hugh Fletcher.

Mr. Weston has also visited Côte St. Pierre, where he has collected as large a series of specimens as possible of *Eozoon* for exhibition in the museum and for distribution.

Mr. H. M. Ami has been occupied chiefly in the classification and labelling of fossils in the museum. All the species enumerated in Mr. Whiteaves' recently published Report on the Invertebrata of the Laramie and Cretaceous rocks of the Bow and Belly Rivers and adjacent localities in the North-West Territory, and the fossil plants of the "Jurasso-Cretaceous," Cretaceous and Laramie rocks of the North-West Territory, described by Sir William Dawson in 1885 and 1886, have been labelled, classified and placed upon exhibition in the museum. A number of fossils from the Devonian rocks of the North-West and Hudson's Bay Territory, and the whole series of fossil plants from the Carboniferous formation of New Brunswick, Nova Scotia and Cape Breton, in the possession of the Survey, have also been labelled and classified.

Collections of fossils made by Professor L. W. Bailey, Messrs. Hugh Fletcher, W. McInnes and W. H. T. Reed, at various localities in the provinces of Quebec, New Brunswick and Nova Scotia, consisting in

* Part P of this volume.

all of some eight hundred specimens (some of which appear to belong to species not previously represented in the museum) have been examined with a view to determine, as far as possible, the exact geological horizons of the rocks from which they were collected. The Palæozoic fossils collected by Mr. R. G. McConnell in 1885 from eight different localities in the Rocky Mountains, and in the early part of the season of 1886 from the Bow River Pass, have also been examined and provisional reports thereon prepared. The Cambro-Silurian fossils collected by Mr. F. D. Adams, in 1885, at Lake St. John, and those collected by Colonel Grant on the Island of Anticosti in the same year (which latter were sent to the Colonial and Indian Exhibition), have been studied, and the species determined.

Collections of duplicate fossils, &c., have been sent to the Redpath Museum at Montreal, to the museums of Queen's University, Kingston, and of the University of Fredericton, N.B., also to those of the Agassiz Association of Montreal, and of the public schools at Berlin and Blair, Ont.

During two months of the year, Mr. Ami has been engaged in the field in the examination of fossiliferous rocks at various localities in the Eastern Townships of the province of Quebec, and in central Ontario, with the object of determining their exact geological horizons, as already stated on pages 20 A and 36 A.

The following collections have been received during the year from members of the staff or gentlemen engaged in the work of the Survey:—

R. Bell :—

One Harp Seal (*Phoca Grœnlandica*) from Blanc Sablon.

One Peregrine Falcon (*Falco communis*) from Cape Chudleigh, Labrador.

One Gyr Falcon (*Falco sacer*) also from Cape Chudleigh.

One King Eider (*Somateria spectabilis*) from Ashe's Inlet, Hudson's Strait.

One Long-tailed or Buffon's Skua (*Stercorarius cepphus*) from Cape Chudleigh.

One Glaucous Gull (*Larus glaucus*) from Resolution Island, Hudson's Strait.

One Ivory Gull (*Pagophila eburnea*) from Resolution Island.

One Kittiwake Gull (*Rissa tridactyla*) from Cape Chudleigh.

One Fulmar Petrel (*Procellaria glacialis*) from Resolution Island.

Two Black-throated Divers (*Colymbus arcticus*) from near Cape Digges, Hudson's Bay.

Thirty-six specimens of fossils from the Albany River between its mouth and the forks.

Twenty-one specimens of fossils from the Attawapishkat River.

R. G. McConnell;—

(From the Rocky Mountains near the line of the Canadian Pacific Railway):—

One specimen of the Hoary Marmot or "Siffleur" (*Arctomys pruinosus*) from mountains near Devil's Head Lake.

One specimen of the Rocky Mountain variety of Parry's Marmot (*Spermophilus Parryi*, var. B.) from the base of Castle Mountain.

One specimen of the Missouri Ground Squirrel (*Tamias quadrivittatus*) from the base of Grotto Mountain.

One Red Squirrel (*Sciurus Hudsonius*, var.) from the base of Wood Mountain.

One Virginian Owl (*Bubo Virginianus*) from Gap Siding, C.P.R.

About 700 specimens of Palæozoic and 100 of Mesozoic fossils.

J. B. Tyrrell and D. B. Dowling:—

(From the Upper North Saskatchewan and its vicinity.)

One Coyote or Prairie Wolf (*Canis latrans*) from Egg Lake.

Two Badgers (*Taxidea Americana*) one from Sounding Creek, and one from Dried Meat Lake, near Battle River.

One Striped Gopher (*Spermophilus tridecemlineatus*) from Nose Creek.

Two Northern Pocket Gophers (*Thomomys talpoides*) from near Edmonton.

One specimen of the western variety of the White-Footed Mouse (*Hesperomys leucopus*, var. *occidentalis*.)

One specimen of Cooper's Shrew (*Sorex personatus*) from Pigeon Lake.

Fifty-two skins of Birds, including three Magpies (*Pica melanoleuca*, var. *Hudsonica*), one Swainson's Buzzard (*Buteo Swainsoni*), two Avocets (*Recurvirostra Americana*), one Wilson's Phalarope (*Steganopus Wilsoni*), one Black-tailed Godwit (*Limosa Hudsonica*), two Willets (*Totanus semipalmatus*), two Upland Plovers (*Actiturus Bartramius*), one White Pelican (*Pelecanus trachyrhynchus*), and two Sooty Terns (*Hydrochelidon lariformis*.)

Eggs of Swainson's Buzzard, Avocet and Upland Plover.

One hundred and twenty-five butterflies, and a small series of fresh-water shells.

About four hundred specimens of Cretaceous and Tertiary fossils.

T. C. Weston :—

Six hundred and eighty specimens of fossils from various localities near Arisaig, N.S.

Twenty-four specimens of fossils from Lochaber, Antigonish county, N.S.

Thirty-six	do	do	do	Escasoni, C.B.
Eighty	do	do	do	George River, Bras d'Or, C.B.
Forty-five	do	do	do	Lévis, Que.

One hundred and twenty-five fossil plants from the Devonian rocks at various localities in Nova Scotia.

A. P. Low :—

Fifty-four specimens of fossils from the Cambro-Silurian or Silurian rocks of limestone rapid on the Fawn branch of the Severn River.

A. C. Lawson :—

Black variety of the Wood Chuck (*Arctomys empetra*) and five fresh-water shells (three *Unio luteolus* and two *Anodonta Footiana*) from Rainy Lake.

H. M. Ami :—

About one thousand specimens of fossils from the Cambro-Silurian and Silurian rocks at various localities in the provinces of Quebec and Ontario.

Seventy-two specimens of fossils from the Post-Pliocene nodules of Green's Creek, near Ottawa, Ont.

L. W. Bailey :—

About six hundred specimens of fossils, chiefly of Silurian age, from different localities in the provinces of Quebec and New Brunswick or from the adjacent parts of Maine.

W. McInnes :—

Ninety specimens of fossils from the Silurian and Devonian rocks of New Brunswick.

R. Chalmers :—

Fifty specimens of fossils from the Upper Devonian rocks of Scaumenac Bay, Que.

Four arrow-heads, a number of quartz chipped flakes and an ancient iron axe head, all from the Tabusintac River, N.B.

Walrus bones from Miscou Island, N.B.

The additions to this branch of the museum, by presentation and purchase, are as follows :—

By Presentation :

The Department of Marine :—Specimens of the following species of mammals, birds, &c., all collected by Mr. F. F. Payne, in 1886, at Cape Prince of Wales, Hudson's Strait :—

Two Arctic Foxes (*Vulpus lagopus*) in summer fur; three Hudson's Bay Lemmings (*Cuniculus torquatus*) two in summer and one in winter fur, and one Polar Hare (*Lepus timidus*, var. *arcticus*) in winter fur.

One Stone Chat (*Saxicola oenanthe*) the first known to have been taken in Canada; one Shore Lark (*Eremophila alpestris*); one Water Thrush (*Siurus nævius*); one Lapland Longspur (*Plectrophanes Lapponicus*); one Raven (*Corvus corax*); one immature Gyr Falcon (*Falco sacer*) in very dark plumage; one Rough-legged Buzzard (*Archibuteo lagopus*); two Rock Ptarmigans (*Lagopus rupestris*) one in full summer, the other in winter plumage; one Ring-necked Plover (*Ægialitis semipalmatus*); pair of red Phalaropes (*Phalaropus fulicarius*); one purple Sandpiper (*Tringa maritima*); one White-rumped Sandpiper (*Tringa Bonaparti*); male Brant Goose (*Bernicla brenta*); one Hutchins' Goose (*Bernicla Hutchinsi*); two Long-tailed Ducks (*Harelda glacialis*), one male in summer plumage and one female; one Harlequin Duck (*Histrionicus torquatus*) adult male; one Herring Gull (*Larus argentatus*); one common Tern (*Sterna hirundo*); one Great Northern Diver or Loon (*Colymbus torquatus*); one male Red-throated Diver (*Colymbus septentrionalis*); three Black Guillemots (*Uria grylle*), one an adult male in summer plumage and two in winter plumage; and one little Auk (*Mergulus alle*), Four Eggs of the Shore Lark, twenty-two of the Water Thrush, twenty-four of the Snow Bunting (*Plectrophanes nivalis*), eight of the Ring-necked Plover, four of the King Eider (*Somateria spectabilis*), five of the Herring Gull, one of the Common Tern, two of the Red-throated Diver, and seven of the Black Guillemot.

One rather large variety of the Speckled or Brook Trout [*Salvelinus fontinalis*).

Department of Fisheries :—

One Black Porpoise (*Phocæna communis*) and one Hooded Seal (*Cystophora cristata*) both stuffed.

Smithsonian Institution, Washington :—

Specimens of the following shells, viz.: Five *Strombus gigas*, two *Tridacna elongata*, two *Mopalia Wossnessenskyi*, two *Pteroceras bryoniæ*, one *Triton tritonis*, one *Fusus proboscidiferus*, one *Cassis cornutum*, one *Spondylus sp.*, and six *Capsa deflorata*.

Dr. R. Bell, Ottawa :—

Black variety of the American Hare (*Lepus Americanus*) from the Hudson Bay district.

Dr. Percy M. Mathews, York Factory, Hudson's Bay:—

One Weasel or Ermine (*Putorius ermineus*) in winter fur, and one young Musk Rat (*Fiber zibethicus*) both from Fort Severn, Hudson's Bay. One Belted Kingfisher (*Ceryle Alcyon*) from Fort Severn. One Golden-winged Woodpecker (*Colaptes auratus*) and one Goshawk (*Astur palumbarius*) from York Factory; three Goslings of the Canada Goose (*Bernicla Canadensis*) and one Lesser Scaup Duck (*Fulix affinis*) from Fort Severn; one Long-tailed Duck (*Harelda glacialis*) in spring and one in autumn plumage, and one King Eider (*Somateria spectabilis*) all from York Factory; two Surf Scoters (*Œdemia perspicillata*) from Fort Severn; and one Black Guillemot (*Uria grylle*) from York Factory. These, though presented in 1885, were not received until 1886.

Arthur Laperrière, Temiscaming :—

Fine specimen of the Ringed Seal (*Phoca* (*Pusa*) *fœtida*) from Cape Digges, Hudson's Bay.

W. Skinner, Toronto :—

Specimen of the Harbor Seal (*Phoca vitulina*) from Nackvak, Northern Labrador, and siphuncle of a species of *Orthorceras*, from Fort Churchill, Hudson's Bay.

Sir William Dawson :—

Twenty-eight species of marine shells and seven of echinodermata from the Gulf of St. Lawrence.

Montague Chamberlain, St. John, N.B. :—

One Merganser (*Mergus merganser*), pair of Long-tailed Ducks (*Harelda glacialis*), one Kumlien's Gull (*Larus Kumlieni*), one Great Black-backed Gull (*Larus marinus*), two Gulls, immature, one young Cormorant (*Graculus carbo?*), two young Loons (*Colymbus torquatus*), and two Red-necked Grebes (*Podiceps Holbolli*.

James Deans, Victoria, B.C. :—
Three fine specimens of a *Trigonia* (probably *T. intermedia*, Fahrenkohl), one of *Thracia semipalmata*, one of *Unio Hubbardi*, a cast of an *Inoceramus*, one *Stephanoceras cepoides;* a fossil fruit (*Dioonites Columbianus*) two pieces of fossil wood and three concretions, all from the Middle Cretaceous rocks of the Queen Charlotte Islands.

Walter R. Billings, Ottawa :—
Two specimens (each the *types*) of *Archæocrinus desideratus* and *Euspirocrinus obconicus*, from the Trenton Limestone of Ottawa.

Andrew B. Henderson, Ottawa :—
Skull of Black Bear (*Ursus Americanus*) and do. of Beaver (*Castor fiber*) from the Sturgeon River.

W. G. Allan, Marlbank, Ontario :—
Stone implement of Indian manufacture.

W. Moore, Bowesville, Ont. :—
Stone gouge from the Black Rapids on the Rideau River.

Rev. W. A. Burman, Griswold, Ont. :—
Skin of Striped Gopher (*Spermophilus tridecemlineatus*) and skin of Ermine (*Putorius ermineus*), also two roots of "Cree Turnip" (*Psoralea esculenta*) as prepared for food by the Indians; all from Manitoba.

F. R. Latchford, Ottawa :—
Six fresh-water bivalve shells, viz., four *Unio nasutus* from Toronto Bay, and two *Unio borealis* from the Ottawa River).

James Fletcher, Ottawa :—
One Jumping Mouse (*Zapus Hudsonicus*), two Field Mice (*Arvicola*), one Striped Gopher (*Spermophilus tridecemlineatus*), and a Snake; all from Regina.

P. B. Winning, Plantagenet, Ont. :—
Specimens of characteristic fossils of the Trenton Limestone of that locality.

T. A. Burrows, Winnipeg :—
Fine specimen of the left valve of *Inoceramus problematicus*, from the Cretaceous rocks of Vermilion River, Riding Mountain, Manitoba.

H. K. Jordan, Newport, Monmouthshire:—
Specimen of *Buccinofusus Berniciensis*, a rare deep sea shell from the Dogger Bank, coast of Northumberland, and ten species of British Chitonidæ.

Lyndwode Pereira, Ottawa:—
Stone Maul from the Qu'Appelle District.

R. L. Johnston, Banff, N.W.T.:—
Rocky Mountain Rat (*Neotoma cinerea*).

W. Craig, Russell, Ont.:—
Adult male Porcupine (*Erethizon dorsatus*) from the township of Russell.

Samuel Edey, Aylmer, Que.:—
Short-eared or Marsh Owl (*Asio brachyotus*) from Aylmer, Q.

J. G. Vincent, Osnaburgh House, *via* Wabigoon, C.P.R.:—
Two fossil shells from the Albany River.

T. Probert, New Edinburgh, near Ottawa:—
Female Marsh Harrier (*Circus Hudsonicus*).

By Purchase:—
Skin, &c. (since mounted), of Northern Fur Seal (*Callorhinus ursinus*) from the west coast of Vancouver Island, and skeleton of another specimen of the same, which latter has been cleaned and mounted by Mons. Jules F. D. Bailly.
One Blue Jay (*Cyanurus cristatus*), one Barred Owl (*Syrnium nebulosum*), one Acadian Owl (*Nyctale Acadica*), and a pair of Snowy Owls (*Nyctea Scandiaca*); all from the neighborhood of Ottawa City.
One Kildeer Plover (*Œgialitis vociferus*), and a young Eared Grebe (*Podiceps auritus*); both from the vicinity of Toronto.
Two Cretaceous fossils, one *Placenticeras placenta*, var. *intercalaris* and an unusually large and perfect specimen of *Cyprina ovata*, var. *alta*, from the Bow River.

Some large and interesting exotic shells have also been acquired by exchange with Prof. H. A. Ward, of Rochester, N. Y.

Botany.

Prof. John Macoun was occupied during the early part of the past year in completing the third part of his catalogue of Canadian plants and in preparing a collection of Canadian plants for display in connection with the Colonial and Indian Exhibition. Prof. Macoun left on the 8th of April for England, returning to Ottawa at the close of his duties in connection with the Exhibition on the 29th of November.

The third part of the catalogue of Canadian plants above referred to, including a complete index to the first three parts, is a pamphlet of 228 pages. The three parts now published are arranged to bind together as a volume, which incloses in all 623 pages, and enumerates all the known dicotyledonous plants of the Dominion, with the geographical range and synonomy of each, constituting a *flora* of the Dominion, though without description of species. The volume contains the names of 101 orders, 584 genera and 2,207 species, exclusive of varieties. In consequence of Prof. Macoun's absence, much of the work connected with the preparation of the index to the first volume was attended to by Mr. J. M. Macoun, while, for the same reason, Mr. James Fletcher, of the Parliamentary Library, devoted a large amount of time and attention to the critical revision of the proof-sheets during the printing of the work.

The only important collection made during the past year is one by Mr. J. M. Macoun, while acting as assistant to Mr. A. P. Low, in the country between Lake Winnipeg and Hudson's Bay.

While in England, in connection with the Colonial and Indian Exhibition, Prof. Macoun devoted himself to giving information in regard to the collection of woods and natural products shown there, in which much interest was manifested, both from a strictly scientific point of view and in their commercial bearings. Relations were also established with various institutions, which will prove of advantage in connection with the prosecution of the botanical work.

In addition to the work above mentioned, as having been performed by Mr. J. M. Macoun, while acting as assistant to Prof. Macoun, he has mounted for the Herbarium during the past year 1,367 sheets of specimens of Canadian, United States and European plants.

These have been sent to various institutions and individuals in exchange for other specimens, or in consideration of assistance rendered in the prosecution of the work.

CHEMISTRY AND MINERALOGY.

Mr. G. C. Hoffmann furnishes the subjoined summary of work carried out by him, or under his direction, in the laboratory of the survey, with a list of donations to the mineralogical section of the museum. In addition to the work mentioned in Mr. Hoffmann's report, he has devoted a portion of his time to superintending the arrangement of the specimens in the museum, and in determining and naming them.

In accordance with the practice of preceding years, the work carried out in the chemical laboratory during the past year, may, on the whole, be said to have been of a purely practical character; the time having been almost entirely occupied in the examination and analysis of such minerals, etc., as were considered likely to prove of commercial importance. The work embraced:—

I—Analyses of numerous iron ores.

II—Analyses of copper and manganese ores.

III—Analyses of platinum ore.

IV—Analyses of several mineral waters.

V—Gold and silver assays—The number of which far exceeded that of any preceding year.

VI—Miscellaneous examinations—under which heading are included cement-stones, marls, saline deposits, etc., etc.

There has been a very marked increase in the number of mineral specimens received for examination; these amounted to five hundred and forty-six, as compared with three hundred and thirty-nine for last year. By far the greater number of these were brought by visitors, and the results of the examination, together with information in regard to their economic value, were, in most instances, communicated in the course of a personal interview. The number of letters written amounted to one hundred and fifty-one, the majority of which constituted reports embodying the results of the examination, analysis or assay of mineral specimens—chiefly those received from distant parts.

Mr. F. D. Adams, assistant chemist, was engaged in laboratory work up to the close of the first week in April, when he left for England on matters connected with the Colonial and Indian Exhibitlon. Mr. E. B. Kenrick, who has been acting as junior assistant chemist, merits commendation for the diligence with which he has applied himself to the work entrusted to him.

In the mineralogical section of the museum many of the old specimens have been replaced by better ones, and one hundred and fifty-one new ones added, including the following presentations:—

Allan, W. A., Ottawa:—
Four specimens of muscovite, from the Villeneuve mica mine, Villeneuve, Ottawa county, Que.

Elwyn, T. Victoria, British Columbia:—
Platinum ore, from Granite Creek, Similkameen River, B.C.

Ells, R. W., of the Geological and Natural History Survey, Ottawa:
Steatite, from Gouverneur, Lawrence county, N.Y.
Asbestus, from Maryland, U.S.A.
Asbestus, from Italy.
Asbestus yarn and sheeting, manufactured from the asbestus of Thetford, Megantic county, Quebec.

Fletcher, James, Ottawa:—
Chabazite, from the Bay of Fundy, N.S.
Concretionary nodule, from Green's Creek, Gloucester, Carleton county, Ont.

Harrington, Dr. B. J., Montreal: —
Sodalite, from Mount Royal, Montreal, Que.
Huronite, from between Lochalch and Missinabi stations, C.P.R.

Hill, Albert J., C.E., New Westminster, British Columbia:—
Molybdenite, from Lillooet River, vicinity of New Westminster, B.C.

Keefer, T. A., Port Arthur, Ont.:—
Five specimens of argentite and one specimen of argentite associated with native silver, from the Porcupine mine, district of Thunder Bay, Ont.

Kirkland, ——, Port Arthur, Ont.:—
Two specimens of native silver from the Beaver mine, district of Thunder Bay, Ont.

Leatch, J. A., Ottawa:—
Specular iron ore, from Shefford, Shefford county, Que.

Moberly, H. J., Fort Vermilion, N.W.T.:—
Four specimens of gypsum, from Peace Point, Peace River, N.W.T.

Onésime Frère, Professeur d'histoire naturelle, Pensionnat des Frères des Ecoles Chrétiennes, Lyons (Rhône), France:—

Arseniosiderite, from a manganese bed at Romanêche, Department of Saône-et-Loire, France. A rare mineral found only at this locality, and then but at rare intervals.

Walchowite, from between Thonon and the Château des Allignes, Haute Savoie, France.

Amianthus (fibrous hornblende) from the Piedmontese Alps, Italy.

Talc, from the quarry of Braly, near Pinnerolo, Piedmont, Italy.

Vangnerite, from Vangnerais, near Lyons, France.

The foregoing are all handsome specimens.

Powell, E. Grant, Ottawa:—

An association of quartz, mica and apatite, from the township of Miller, Frontenac county, Ont.

Specimens of mica, with inclusions, from the same locality.

Reed, Dr. James, Reedsdale, Megantic county, Que.:—

Specimens of chromite from the townships of Thetford, Coleraine and Leeds, Megantic county, Que.

Rehm, Gustav Von, Ottawa:—

Specimen of muscovite, with inclusions of garnet, from the Villeneuve mica mine, Villeneuve, Ottawa county, Que.

Rhodes, Curry & Co., Amherst, N.S.:—

A specimen of red sandstone (cube, dressed), from Amherst, N.S.

Russell, M. L., Renfrew, Ont.:—

Pyrrhotite, from the township of McKin, near Sudbury, district of Nipissing, Ont.

Shirley, L. H., C.E., Buckingham, Ottawa county, Que.:—

A crystal of black tourmaline, from Wakefield, Ottawa county, Que.; and the following from the Villeneuve mica mine, Villeneuve, Ottawa county, Que.:—

Five specimens of microcline.

Specimens of quartz.

An association of quartz, muscovite, albite and garnet.

Specimens of albite.

A large fragment of albite (in association with some muscovite, a little quartz and garnet) penetrated by crystals of black tourmaline. This is a very handsome specimen.

Torrance, J. F., Montreal:—

Infusorial earth, from Folly Lake, Colchester county, N.S.

Treen & Fish, Newcastle, N.B. :—
A specimen of grey sandstone (cube, dressed), from the vicinity of Newcastle, Northumberland county, N.B.

Welden, F. C., Grenville, Que. :—
A specimen of disseminated graphite, from Grenville, Argenteuil county, Que.

Wylie, W. H., Carleton Place, Ont. :—
Two specimens of barite, from Pakenham, Ont.

Young, James :—
A specimen of dolomite (cube, dressed), from the Narrows of Lake Manitoba.

Mr. C. W. Willimott was actively engaged, up to the time of his departure for England, at the close of March, in receiving, cataloguing and packing the mineral collection for the Colonial and Indian Exhibition.

The greater part of Mr. R. L. Broadbent's time has been devoted to the permanent labelling of the mineral collection, re-adjusting of some of the cases, and work of a like nature. He has made up and catalogued six mineral collections, comprising 340 specimens, for distribution. He also rendered some assistance to Mr. Willimott, and, after the latter's departure, attended to matters connected with the shipment of such goods as arrived too late to be forwarded with the first consignments.

Maps.

The greater part of the time of Mr. S. Barlow, chief draftsman, has been devoted, as usual, to the general superintendence of the mapping work, and in discussing the material for the selection of fixed points in the various sheets in progress.

Mr. Barlow furnishes the following memoranda of maps completed, or in course of completion :—

British Columbia.—A map of the western part of Vancouver Island and adjacent coast on a scale of eight miles to an inch, which is intended to illustrate a forthcoming report on the geology, is now nearly ready for the engraver. Mr. Bowman's revised map of the southern interior of the same province is in the draftsman's hands, and will probably be finished this winter. The map of the Cariboo mining district is also in course of compilation, and will be pushed through as rapidly as possible.

British Columbia and North-West Territory.—Dr. Dawson's map of a portion of the Rocky Mountains, mentioned in the last summary report, has been completed and published as a reconnaisance map, including all available information up to date.

North-West Territory.—A map of the Cascade coal basin, on a scale of 1½ inch to the mile, in the Rocky Mountains, has been drawn and photo-lithographed, and is published in Dr. Dawson's report. Mr. McConnell's map of the Cypress Hills and Wood Mountain has been engraved and published. Mr. J. B. Tyrrell's map, comprising the third sheet on an uniform scale of 8 miles to an inch, and including the country between the upper parts of the Bow and North Saskatchewan rivers, will, it is hoped, be completed for publication in a few months.

Manitoba and Western Ontario.—Mr. Lawson's map of the Lake of the Woods and its vicinity is in the hands of the engraver, and will very shortly be published; various unforeseen difficulties, in connection with the topography of this map, have unavoidably delayed its publication. Work to the south and south-east of the above sheet, also carried out by Mr. Lawson, is in the draftsman's hands, but will not be completed for publication before the work of another season in the field is available.

Ontario.—Mr. E. D. Ingall has, in the course of completion a contoured map of Silver Mountain and vicinity, Thunder Bay district. This covers an area of forty square miles, and will be published in a few months.

Mr. Cochrane has continued the work of last season in sheet No. 115, referred to as in course of revision in the last summary report. During the past season he was occupied from June 28th to October 24th in examining and correcting 900 square miles of the area embraced, leaving about 300 square miles to be revised before the completion of the sheet. In the course of this work, various measurements were made where found necessary. The progress of the mapping work by Mr. Coste and assistant is referred to elsewhere. Copies of 57 township plans in Ontario have been procured, and about 750 miles of railway lines, on a large scale, have been copied, for the purpose of checking and correcting the township surveys.

Quebec.—The map of Lake Mistassini has been published in Mr. Low's report. In the course of Mr. Ells' examination of a part of the Eastern Townships, a number of road surveys have been made, and are being added to the engraved map. It has been found impossible, owing to

the press of work in the office, to add much to the map of Ottawa and Pontiac counties during the past year.

New Brunswick.—One sheet (plan 2 S.W.) has been published.

Nova Scotia.—One sheet (plan 4 N.W.) has been published.

The work in progress in Nova Scotia and New Brunswick, with surveys carried out in the region between Hudson Bay and Lake Winnipeg, is fully noticed in connection with the field work of the various parties.

LIBRARY.

The Librarian, Dr. Thorburn, reports that during the year 1886, from January 1st to December 31st, 8,185 copies of the Geological and Natural History Survey publications were distributed; of these, 6,924 were distributed in Canada; the remainder, 1,261, were sent as exchanges to scientific and literary institutions and individuals in America, Europe, India, Japan and Australia, &c.

Seven hundred and twelve publications, including books, transactions, memoirs, periodicals, pamphlets and maps, were received as exchanges. There were added to the library, during the year, by purchase, 101 volumes, besides 43 scientific magazines and periodicals on geological, mineralogical and natural history subjects which were subscribed for.

During the year 189 volumes were bound. There are now in the library about 6,500 volumes. The number of letters received was 1,060, the number sent out, 898.

During the past year a card catalogue has been completed, and is now in use. It will be found to be of great practical value, and will materially assist the members of the Geological Survey in finding, more readily than formerly, what books there are in the library which treat of any subject on which information is wanted.

VISITORS.

The number of visitors to the museum during the year ended 31st December, 1886, was 14,465, an increase, as compared with the previous year, of 1,022.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The strength of the staff at present employed is 50, viz., professional, 34, ordinary, 16.

During the year the following promotions were made in the permanent staff:—

Messrs. L. M. Lambe and A. P. Low from third class to second class clerks.

The amount available for the fiscal year ended 30th June was:—

Civil list salaries, appropriation	$ 36,200 00
General purposes do	78,853 01
Total	$115,053 01

The expenditure may be summarized under the divisions named as follows:—

Pay-list salaries	$ 35,936 03
Wages, temporary employees	19,142 65
Exploration and survey	36,395 44
Printing and lithography	15,383 45
Purchase specimens	1,722 05
Purchase books and instruments	3,334 16
Laboratory apparatus and chemicals	329 14
Stationery	591 89
Incidental and other expenses	3,828 02
	$116,662 83
Less paid in 1885	11,006 59
	$105,656 24
Advances to field explorers and others on account 1886–87	8,837 48
Unexpended balance civil list appropriation	268 97
Unexpended balance contingency appropriation	295 32
	$115,053 01

The correspondence of the branch shows a total of 10,673 letters sent, and 8,420 received.

I have the honor to be, Sir,

Your obedient servant,

ALFRED R. C. SELWYN,

Director.

ADDITIONS TO THE LIBRARY.

FROM JANUARY 4TH TO DECEMBER 31ST, 1886.

CANADA.

Department of Inland Revenue, Ottawa :—

Report, Returns and Statistics of the Dominion of Canada. 1885.

Report on Canal Statistics, Supplement No. 1 to Report for 1885.

Report on Inspection of Weights and Measures, Supplement No. 2 to Report for 1885.

Report on Adulteration of Food, Supplement No. 3 to Report for 1885.

Department of Agriculture, Ottawa :—

Report from 1869-73.

Report for year 1885.

Appendix to Report for 1885 (3 copies).

Report on Canadian Archives. 1886.

Colonial and Indian Exhibition. Official Catalogue. 1886.

Report on Agricultural Colleges and Experimental Farm Stations, with suggestions relating to Experimental Agriculture in Canada, W. Saunders, 1886.

Canada : its Resources, History and Natural Productions, Ottawa. 1886.

Department of Justice, Ottawa :—

Report of Minister. 1885.

Department of Public Works, Ottawa :—

Annual Report, 1885.

Auditor-General's Office, Ottawa :—

Estimates for year ending June, 1887.

Report on Appropriation Accounts. 1885.

Department of Marine, Ottawa :—

Eighteenth Annual Report. 1885.

Report of the Hudson's Bay Expedition Under Command of Commander Gordon, R.N., 1885.

Charts of Temperature of H. B. region. 1884-85.

Georgian Bay Channel Pilot, Chaps. 1, 2, 1886, Cabot Head to Cape Smith, Commander Boulton, R.N.

Department of Fisheries, Ottawa :—

Annual Report. 1885.

Catalogue of Canadian Pinnipedia Cetacea, Fishes and Marine Invertebrata, by J. F. Whiteaves. Colonial and Indian Exhibition. 1886.

Department of the Interior, Ottawa:—
Annual Report. 1885.
Descriptions of the Townships of the N.W. Territory, W. 4th and 5th Initial Meridian. 1886.
Report of the Commissioner of N. W. M. Police. 1885.
Detailed report upon all Claims of Land and right to participate in the North-West Half-Breed Grant by settlement along the South Saskatchewan, &c. 1886.

Department of Militia, Ottawa:—
Annual Report. 1885.
Report upon the Suppression of the Rebellion in the North-West Territories and Matters in Connection therewith in 1885.

Department Secretary of State, Ottawa:—
Report for 1885.
Civil Service List of Canada. 1886.
Report Board of Civil Service Examiners of Canada for 1885.

Department of Indian Affairs, Ottawa:—
Annual Report for 1885 (five copies).

Department of Railways and Canals, Ottawa:—
Annual Report. 1885.
Railway Statistics of Canada. 1884-85.
Report Canadian Pacific Railway. 1877.

Post Office Department, Ottawa:—
Report for 1885.
Postal Atlas, Province of Quebec. 1880.
Postal Map of Ontario. (no date.)
Official Postal Guide. 1886.

Department of Customs, Ottawa:—
Trade and Navigation Returns for years 1860-83. 1885.

Department of Finance, Ottawa:—
Shareholders of the Chartered Banks of the Dominion of Canada. 1885.

Canada Gazette, Ottawa:—
Vol. 19. 1885-6.
Vol. 20. 1886-7.

House of Commons, Ottawa.—
Hansard. Vol. 17. 1885.

The Senate, Ottawa:—
Debates of the Senate of Dominion of Canada. Session 1886.

Legislative Assembly, Toronto:—
Journals Vols. 2-10. 1868-77. Vols. 12-18. 1879-85.
Sessional Papers. Vol. 1. Parts 1-2. 1868-9. Vol. 2. 1869. Vol. 3. Parts 1-2. 1870-1. Vol. 4. Parts 1-2. 1871-2. Vols. 5-7. 1873-4. Vols. 9-17. 1877-85.

Commissioner Crown Lands, Toronto:—
Reports 1870-71. 1881-85.

Accounts of the late Province of Canada and the Provinces of Ontario and Quebec with the Dominion of Canada, from July, 1867, to June, 1885.
Public Accounts of Province of Ontario for year 1885.

Manitoba Gazette:
Vol. 15. 1886.

Statutes of the Province of Manitoba. Vol. 1. 1885.
Census of the Three Provisional Districts of the North-West Territory. 1884-85.

Minister of Mines, British Columbia:—
Annual Report. 1885.

Department of Mines, Nova Scotia:—
Report for 1885.
Report of the Committee consisting of Dr. E. B. Tylor, Dr. G. M. Dawson, Sir H. Lefroy, Dr. D. Wilson, Horatio Hale, R. G. Haliburton and G. W. Bloxam, appointed for the purpose of investigating and publishing Reports on the Physical Characters, Languages, &c., of the North-West Tribes of the Dominion of Canada. 1886.

Canadian Institute, Toronto:—
Proceedings (3 ser), Vol. 4. No. 1. 1886.

Le Naturaliste Canadien, Cap Rouge:—
Vol 16. 1886.

Canadian Entomologist, London:—
Vol. 16. No. 12. 1884.

Public Library, Toronto:—
Second Annual Report. 1885.

Field Naturalists' Club, Ottawa:—
Transactions. Vol. 2. No. 1. 1885.

Historical and Scientific Society, Winnipeg:—
Transactions. Nos. 19-21. 1885-6.
Annual Report for year 1885-6.

Université Laval:—
Annuaire 1886-7.

Seminaire de Chicoutimi:—
Annuaire No. 6. 1885-6.

Royal Society of Canada:—
Proceedings and Transactions. Vol. 3. 1885.

Wycliffe College, Toronto:—
Calendar 1885-6.

Commissioner of Crown Lands, Quebec:—
Report. 1868. 1870-85.
Annual Report of the Inspector of Prisons and Public Charities upon the Common Gaols, Prisons, &c., of Province of Quebec. 1885.
Abstract of Life Insurance in Canada for 1885.
Diplome d'Honneur, Exposition Universelle d'Anvers 1885, Awarded to the Geological Survey of Canada. 1885.

AMOS BOWMAN :—
Preliminary Report on Field Notes in Cariboo District, B.C. 1885.

W. A. ALLAN, *Ottawa* :—
Report on the Property of the St. Onge Gold Mining Company, 1886, by Prof. E. J. Chapman.

Dominion Land Surveyors, Ottawa :—
Proceedings. 1886.

Hamilton Association :—
Journal and Proceedings. Vol. 1. Part 2. 1884-85.

Natural History Society, St. John :—
Bulletin No. 5. 1886.

Weekly Sentinel, Port Arthur :—
Vol. 11. Nos. 4, 5. 1886.
Notes on Gaspesia (2nd ed.) 1885.

A. M. MACKAY, *Pictou* :—
Organic Siliceous Remains in the Lake Deposit of Nova Scotia. 1885.
Note on the Fresh-Water Sponges of Nova Scotia. 1886.
New Fresh-Water Sponges from Nova Scotia and Newfoundland. 1886.

REV. D. HONEYMAN, *Halifax* :—
Geological Notes of Excursions with Members of e British Association and others. 1884.

DR. J. B. BAKER EDWARDS, *Montreal* :—
Paper on Arsenical Poisoning due to the Commercial and Domestic Uses of Arsenic. 1885.
School Architecture and Hygiene with Plans and Illustrations for use of School Trustees in Ontario. 1885.

SIR WILLIAM DAWSON, *Montreal* :—
On Rhizocarps in the Erian (Devonian) Period in America. 1886.
The Geological History of the North Atlantic. (Presidental address. B. Association. 1886.)

H. W. GANONG, *St. Stephen, New Brunswick* :—
Is Littorina Litorea Introduced or Indigenous. 1886.

A. K. MONTPETIT, *Levis* :—
L'Amiante c'est le Million. 1884.

C. W. ROBB, *Montreal* :—
Investigations between Mingan and Labrador, by W. Couper. 1868.
Davenport Academy of Nat. Sciences. Vol. 1. 1875-76.
Royal Society's Proceedings, London. No. 219.

PROF. RAMSAY WRIGHT, *Toronto* :—
Summer Camp, with Notes on the Anatomy of Fishes. 1885.

J. G. BOURINOT, *Ottawa* :—
Canada as a Home. 1882.

G. M. DAWSON, *Ottawa* :—
The Canadian Rocky Mountains, with special reference to that part of the

Range between the 49th parallel and the Head Waters of the Red Deer River. 1886.

L'Abbé J. C. Laflamme :—
Le Saguenay, Essai de Géographie Physique. 1886.

E. Seton :—
The Birds of Western Manitoba. 1886.

H. Hale, *Clinton, Ont.* :—
The Origin of Language and the Antiquity of Speaking Man. 1886.

UNITED STATES.

United States Geological Survey, Washington :—
Monograph. Vol. 9. 1885.
Bulletin Nos. 27-30. 1886.
Fifth Annual Report. 1883-4.
Mineral Resources of the United States, by A. Williams. 1883-4.

United States Coast and Geodetic Survey, Washington :—
Report 1884.

Library Surgeon-General's Office, Washington :—
Index Catalogue. Vol. 7. 1886.

Director of the Mint, Washington :—
Fourteenth Annual Report. 1886.

Secretary of the Treasury, Washington :—
Annual Report. 1886.

Census Department, Washington :—
Tenth Census of the United States. Vols. 14, 16, 18, 20. 1885-6.

Smithsonian Institution, Washington :—
Reports for 1883, 1884.
List of Foreign Correspondents of the Smithsonian Institution. 1885.
List of Institutions in the United States receiving publications of the Smithsonian Institution. 1886.

U. S. Entomological Commission :—
Fourth Report. 1886.

Treasury Department, Washington :—
Report upon Alaska and its People, by Capt. G. M. Baily. 1880.
Report of a Military Reconnaisance in Alaska, 1883, by Lieut. F. Schwatka.
Report of the Cruise of the U.S. Revenue Steamer Corwin in the Arctic Ocean, by Lieut. C. L. Hooper. 1880.

Ordnance Department, Washington :—
Annual Report. 1885.

Chief of Engineers U.S. Army, Washington :—
Annual Report. Parts 1-4. 1885.

State Geologist, New York:—

Report for 1882-83-84, accompanied by a Geological Map of the State.

Report of the State Geologist, giving an account of the condition of the work upon which he is engaged. 1881.

Natural History of the State of New York. Palæontology of New York. Vol. 5. Part 1. Nos. 1-2. Text and plates.

American Chemical Society, New York:—

Journal. Vol. 7. Nos. 9, 10. 1885.
" " 8. " 1-8. 1886.

State Museum of Natural History, New York:—

33rd-38th Annual Reports. 1880-85.

American Museum of Natural History, New York:—

Annual Report of Trustees. 1885-86.
Bulletin. Vol. 1. Nos. 6-7. 1885-86.

American Geographical Society, New York:—

Journal. Vol. 1. Nos. 2-10. 1859.
" " 2. No. 2. 1870.
" " 3. 1873.
" " 5. 1874.
" " 6. 1874.
Bulletin. " 1. 1852.
" " 2. 1856.
Proceedings. Vol. 1. Nos. 1-4. 1862-63.
" " 2. " 1-4. 1863-64.

Cornell University, Ithaca:—

Library Bulletin. Vol. 2. Nos. 1-2. 1886.

American Ornithological Union, New York:—

Bulletin. No. 1. 1886.

Academy of Natural Sciences, New York:—

Annals. Vol. 3. No. 9. 1885.
Transactions. Vol. 5. Nos. 4-5. 1886.

Military Service Institution, Governor's Island, New York:—

Journal. Vol. 7. Nos. 25, 26, 28. 1886.

Geological Survey of New Jersey:—

Annual Report. 1885.

Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls, by R. P. Whitfield. 1885.

Engineers' Club of Philadelphia:—

Proceedings. Vol. 5. 1886.

Geological Survey of Pennsylvania:—

Reports of Progress. RR. T3. C5. AA. Also Atlas AA. 1885.

Product and Exhaustion of the Oil Regions of Pennsylvania and New York, by C. A. Ashburner. 1885.

Geology and Natural Gas in Pennsylvania and New York. 1885.

List of Publications of the Survey. 1885.

Annual Report and Atlas. 1885.

Lehigh University, Ithaca :—
Library Bulletin. Vol. 2. No. 1. 1886.

Zoological Society, Philadelphia :—
Fourteenth Report of the Board of Directors. 1886.

University of Vermont and State Agricultural College, Burlington :—
Catalogue. 1885-86.

Museum of Comparative Zoology, Cambridge .—
Memoirs. Vol. 10. No. 2. 1884.
Bulletin. " 12. Nos. 3-4. 1886.
" " 13. No. 1. 1886.
Report of the Curator. 1885-86.

Peabody Academy of Sciences, Salem :—
Eighteenth Annual Report. 1886.

Peabody Museum of American Archæology and Ethnology, Cambridge :—
Eighteenth and Nineteenth Annual Reports. Vol. 3. Nos. 5, 6. 1886.

Appalachian Mountain Club, Boston :—
Appalachia. Vol. 4. No. 3. 1886.
Annual Register. 1886.

American Society of Arts and Sciences, Boston :—
Proceedings. Vol. 13. (N. ser.) Parts 1, 2. 1885-6.

Society of Natural History, Boston :—
Memoirs. Vol. 3. Nos. 12, 13. 1886.
Proceedings. Vol. 23. Part 2. 1884-86.

Harvard University, Cambridge :—
Bulletin. Vol. 4. 1886.
Annual Report. 1884-85.

Brown University, Providence, R.I. :—
Annual Report of the President. 1885-86.
Catalogus Universitatis Brunensis. 1886.

Natural History Society, Newport :—
Proceedings. 1883-84.

Public Library, St. Louis, Mo. :—
Annual Report. 1884-85.

Academy of Natural Sciences, Davenport, Iowa :—
Proceedings. Vol. 4. 1882-83.

Commissioner of Mineral Statistics, Lansing, Michigan :—
Annual Report. 1883-84.

Agricultural College, Lansing, Michigan :—
Bulletin. Nos. 10-21. 1885-86.

The Mining Review, Chicago :—
Vol. 11. Nos. 1-25. 1884.
" 12. Nos. 1-22, 24-25. 1884.
" 13. Nos. 1-4, 6-15, 17-26. 1885.

" 14. 1885.
" 15. 1886.
" 16. 1886.

State Mineralogist, California:—
Fifth Annual Report. 1885.

California Academy of Science:—
Bulletin. Vol. 1. Nos. 1-4. 1884-86.
" " 2. No. 5. 1886.

Geological Survey of Alabama:—
Report on the Warren Coal Field, by H. McCalley. 1886.

American Chemical Journal, Baltimore:—
Vol. 8. 1886.

Geological and Natural History Survey of Minnesota, Minneapolis:—
Fifth Annual Report. 1876.

Geological Survey of Ohio:—
Preliminary Report. 1886.

Society of Natural History, Cincinnati, Ohio:—
Journal. Vol. 9. Nos. 1-2. 1886.

Agricultural Station, Columbus:—
Fourth Annual Report. 1885.

Denison University, Granville:—
Bulletin. 1886.

G. F. BECKER, *U. S. Geological Survey, Washington*:—
The Washoe Rocks. 1885.
A Theorem of Maximum Dissipativity. A new law of Thermo-Chemistry. 1885.

J. LE CONTE, *Berkeley, California*:—
A Post-Tertiary Elevation of the Sierra Nevada, shown by River Beds. 1886.

J. W. JACKSON, *Berkeley, Cal.*:—
Mineralogical Contributions. 1886.

C. H. HITCHCOCK, *Hanover, N.H.*:—
Geological Map of the United States. 1886.

T. V. MUNSON:—
Address on Native Grapes of the United States. 1885.
Address on American Grapes. 1886.

SHELDON JACKSON:—
Report on Education in Alaska, with Maps and Illustrations. 1886.

JAS. W. QUEEN A Co., *Philadelphia*:—
The Microscopical Bulletin. 1886.

W. J. MCGEE:—
Map of the United States. 1884.

A. J. TIFFANY :—

Geology of Scott County, Iowa, and Rock Island County, Illinois. 1885.

W. E. CLAYPOLE :—

On Pteraspidian Fish in the Upper Silurian Rocks of North America. 1885.

A. S. PACKARD, *Providence* :—

Memoirs of Jeffries Wyman. 1814-1874.

Geological Extinction and some of its Apparent Causes. 1886.

A. HAGUE and J. G. IDDINGS :—

Volcanic Rocks of the Republic of Salvador, South America. 1886.

C. D. WALCOTT :—

Classification of the Cambrian System of North America. 1886.

E. O. ULRICH, *Cincinnati* :—

Contributions to Canadian Palaeontology. Vol. 1. 1886.

Cretaceous Metamorphic Rocks of California. 1886.

Report of the Lower Silurian Bryozoa of Minnesota, with Preliminary descriptions of some New Species. 1886.

W. G. RICH :—

Illustrated New Mexico. 1885.

PROF. ROLAND D. IRVING :—

Preliminary Paper on an Investigation of an Archæan Formation of the North Western States. 1885.

C. L. HERRICK :—

A Final Report on the Crustacea of Minnesota included in the orders Cladocera and Copepoda. 1884.

Types of Animal Life selected for Laboratory use in Inland Districts. Part I. Anthropoda. 1885.

PROF. J. J. NEWBERRY :—

Notes on the Geology and Botany of the Country bordering the Northern Pacific R.R. (No date.)

J. H. LEWIS :—

Ancient Rock Inscriptions in Eastern Dakota. 1886.

The "Monumental Tortoise" Mounds of De-coo-dah. 1886.

DR. PERSIFOR FRAZER :—

General Notes on the Geology of New York County, Penn. 1885.

The Application of Composite Photography to Handwriting, and especially to Signatures. 1886.

J. C. RUSSELL :—

Existing Glaciers in the United States. 1885.

JULES MARCOU :—

Explication d'une Seconde Edition de la Carte Géologique de la terre, 1885.

JAS. B. EADS, *New York* :—

Discussion on Paper of E. L. Corthell on the South Pass Jetties. 1885.

M. E. WADSWORTH :—

List of Publications. 1878-85.

On a Supposed Fossil from the Copper-bearing Rocks of Lake Superior. 1884.

The Theories of Ore Deposits. 1884.

On the Relations of the "Keweenawan Series" to the Eastern Sandstone in the Vicinity of Torch Lake, Michigan. 1884.

Lithological Studies: a Description and Classification of the Rocks of the Cordilleras. (No date.)

Syenite and Gabbro in Massachusetts. 1885.

Q. E. DICKERMAN and M. E. WADSWORTH :—

An Olivine bearing Diabase from St. George, Maine. 1885.

J. H. SCUDDER :—

The Cockroach of the Past. 1886.

W. J. HIGLEY, *Lake Geneva, Wisconsin* :—

A paper on Elephas Primogenius. 1886.

On the Northern Pitcher Plant or the Side Saddle Flower. 1886

Carnivorous Plants. 1886.

On the Microscopic and General Characters of the Peach Tree affected by the "Yellows." 1881.

A. W. VOGDES, *Governor's Island, N. Y.H.* :—

Notes on the Distribution of Iron Ores in the United States, compiled from Geological Reports. 1886.

Annual Reports of War Department, Washington, upon the Geographical Survey West of 100th Meredian. App. JJ. 1876.

App. NN. 1877-1878.

App. OO. 1878, and Topographical Sheets, Wheeler. 1876-1877-1878.

Journal of the Royal Military Service Institution. Vol. 7. No. 28. 1886:

Our Sea Coast Defences, by Eugene Griffin. 1885.

Reviews of H. H. Bancroft's History of the Pacific States, from British Quarterly Review and the London Times. 1883.

Ward's Natural Science Bulletin. 1886.

ENGLAND.

Royal Society, London.—

Proceedings.	Vol. 33.	No.	219.
"	" 38.	Nos.	235-8.
"	" 39.	"	239-41.
"	" 40.	"	242-5.
"	" 41.	"	246-7.

Transactions. Vol. 175. 1884.
" " 176. 1885.

List of Fellows. 1884-85.

Royal Geographical Society, London :—

Proceedings. Vol. 8. 1886.

Royal United Service Institution, London :—
Journal. Vol. 30. 1886.

Royal Colonial Institute, London :—
Catalogue of Library. 1886.
Proceedings. Vol. 17. 1885-86.

Geological Society, Manchester :—
Transactions. Vol. 18. 1885-86.

Literary and Philosophical Society, Manchester :—
Proceedings. Vols. 23, 24. 1883-85.
Memoirs. Third Series. Vol. 8. 1884.

Mining Association and Institution of Cornwall, Redruth :—
Transactions. Vol. 1. No. 2. 1886.

Royal Geological Society, Cornwall :—
Transactions. Vol. 10. Part 8. 1886.

Geological Association, Liverpool :—
Transactions. Vol. 5. 1884-85.

Radcliffe Library, Oxford :—
Catalogue of Books. 1885.
List of Donations. 1885.

Radcliffe Observatory, Oxford :—
Results of Observations. 1882.
Observations. Vol. 41. 1883.

Bodleian Library, Oxford :—
List of Donations. 1885.

Journal of Conchology, Leeds :—
Vol. 5. 1886.

European Mail :—
Vol. 69. Nos. 5,392, '94, '95, '97, '98, 5,400, 5,401. 1886.

Meteorological Office, London :—
Observations of the International Polar Expedition. 1882-83. Fort Rae. 1886.

Final Report of Her Majesty's Commissioner appointed to inquire into the accidents in mines, &c., together with evidence and appendices. 1886.

The Pharmaceutical Journal, London :—
Third Series. Nos. 809-860. 1886.

E. A. Ormerod, *Spring Grove, Isleworth* :—
Report of Observations of Injurious Insects and Common Farm Pests during the year 1885, with methods of Prevention and Remedy. 1886.

Hyde Clarke, *London* :—
Researches in Prehistoric and Protohistoric Comparative Philology, Mythology and Archæology in connection with the Origin of Culture in America and the Accad or Sumerian Families. London. 1875.

P. H. Carpenter, *Eton College* :—
Note on the Structure Crotalocrinus. 1886.

H. BRAMALL, *Liverpool* :—
Modern Progress in Mine Engineering. 1884.

PROF. T. G. BONNEY, *London* :—
Address delivered at Anniversary Meeting of the Geological Society, London, February, 1885.
On a Glaucophane-Eclogite from the Val D'Aoste. 1885.
Address to the Geological Section of the British Association at Birmingham. 1886.

H. HICKS, *London* :—
Further Proofs of the Pre-Cambrian Age of certain Felsitic and other Rocks in N.W. Pembrokeshire. 1886.

H. T. MENNELL, *Croydon* :—
Across Canada to the Rocky Mountains from a Botanist's point of view. 1885.

SCOTLAND.

Scottish Geographical Society, Edinburgh :—
Magazine. Vol. 2. 1886.
Index to Vol. 1. 1885.

Botanical Society, Edinburgh :—
Transactions and Proceedings. Vol. 16. Part 2. 1886.

Museum of Science and Arts, Edinburgh :—
Report of the Director. 1885.

Royal Observatory, Edinburgh :—
Astronomical Observations. Vol. 15. 1878-86.

The University, Glasgow :—
Calendar. 1886-87.

Geological Society, Glasgow :—

Transactions.	Vol. 1.	Part 2.	1863.
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"	" 4.	Part 3.	1874.
"	" 5.	Parts 1,2.	1875-77.
"	" 6.	Part 1.	1879-80.
"	" 7.	1881-84.	

PROF. J. CLELAND, *Glasgow* :—
Terminal Forms of Life. (No date.)

Institution of Engineers and Shipbuilders, Glasgow :—

Transactions.	29th Session.	Nos. 1-5.	1885-86.
"	30th "	" 1-2.	1886-87.

IRELAND.

Royal Society, Dublin :—

Transactions.	Vol. 3.	(Ser. 2.)	Nos. 4-10.	1884-85.
Proceedings.	Vol. 4.	(N.S.)	Parts 5-9.	1884-85.
"	Vol. 5.	(N.S.)	Parts 1-2.	1886.

AUSTRALASIA.

VICTORIA.

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G. M. DAWSON, PHOTO., 10 SEPT., 1885. IVES-PROCESS; G. E. DESBARATS & SON, MONTREAL.

MĀMELILIAKA VILLAGE, VILLAGE ISLAND,
NEAR ENTRANCE TO KNIGHT'S INLET, BRITISH COLUMBIA.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON A GEOLOGIAL EXAMINATION OF THE

NORTHERN PART OF

VANCOUVER ISLAND

AND ADJACENT COASTS.

BY

GEORGE M. DAWSON, D.S., F.G.S.

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MONTREAL:
DAWSON BROTHERS.
1887.

To ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S.

Director of the Geological and Natural History Survey of Canada.

SIR,—I have the honor to present herewith a report on the northern part of Vancouver Island, from Comox to Quatsino Sound, with the coasts of adjacent islands and portions of the mainland. This report embodies the results of work done in 1885, together with that of some examinations carried out in 1878, which were at the time regarded as incomplete. This report is of a preliminary character, the explorations to which it relates having been for the most part confined to the shores, and directed specially toward ascertaining the character and extent of the areas of Cretaceous coal-bearing rocks.

I have the honour to be, sir,

Your obedient servant,

GEORGE M. DAWSON.

OTTAWA, March 1, 1887.

NOTE.—The bearings throughout this report are given with reference to the true meridian, unless otherwise specially noted.

Distances are stated in nautical miles, as measured on the Admiralty charts.

The native names of places which are divided into syllables, have been correctly ascertained, and in these the vowels are uniformily employed with their 'continental' values. The pronunciation of other Indian names has either not been accurately ascertained, or their orthography has already become so fixed in previous publications, as to render it inadvisable to change them.

REPORT

ON A GEOLOGICAL EXAMINATION OF THE

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GEORGE M. DAWSON, D.S., F.G.S.

The field-work upon which the present report is based, occupied the greater part of the season of 1885, the party leaving Victoria on the 21st of June, and returning to the same point on the 22nd of October. It was intended to continue the exploration in the following summer, and to supplement the information gained by an examination of the shores, in 1885, by a number of selected traverses into the interior of Vancouver Island, but this having proved impossible, the report on the work of 1885 is here presented, together with a first edition of a geological map of the northern portion of Vancouver Island, which it is to be hoped may ere long be republished in a more complete form. In the following synopsis of results, special prominence is given to the facts bearing on the Cretaceous coal-bearing rocks of the region. **Nature of Report and map.**

A short preliminary account of the work of 1885 has already been given in the Summary Report for that year, forming Part III. of the Report of the Department of the Interior, and reprinted in the first part of the Annual Report of the Geological Survey for 1885 (p. 39 A, *et seq*).

The portion of the seaboard of British Columbia, heretofore geologically investigated, has been comparatively limited. The late Mr. James Richardson cursorily examined a number of points, and has furnished valuable notes on these in his various reports, but his detailed work on the coast was practically confined to the coal-bearing Cretaceous areas of the south-eastern part of Vancouver Island, including, more particularly, those of Nanaimo and Comox. His final report on **Previous geological work on the coast.**

the Nanaimo and Comox regions, with other less important areas of coal- or lignite-bearing rocks, is published, with a geological map on a scale of four miles to an inch, in the Report of Progress for 1876–77. In 1878, the writer explored and surveyed the greater part of the coast-line of the Queen Charlotte Islands, details respecting which are given in the Report of Progress for 1878–79. In the same year, some reconnaisance work was effected in the northern part of Vancouver Island, including parts of Quatsino Sound, but this was not judged to be sufficiently complete for publication. The increasing interest in the resources of the province of British Columbia, and the fact that efforts were actually in progress to develop coal-fields north of those of Comox, rendered it desirable to ascertain more precisely the extent and probable value of these northern coal-fields, and the work undertaken in 1885 was, in consequence, largely devoted to this end.

Mode of prosecuting work. A small schooner was chartered in Victoria to serve as a means of locomotion and basis for operations, and surveys were conducted along the shores, generally by means of boats and canoes. The best and most instructive sections occur along the coast-line, and attention was consequently restricted chiefly to these, though some bush traverses were also made for the purpose of ascertaining the width of the areas of Cretaceous coal-bearing rocks met with. It was endeavoured to make the examination of such parts of the coast as were gone over, so complete as to obviate the necessity of its revision, but where extended inland work appeared necessary to complete the geological outlines, it was thought better to postpone this till all the information possible had been gained by examinations of the coast sections. While therefore, the result of the work of the season must be regarded as strictly preliminary, in so far as the country in general is concerned, the outlines of formations on the coast are proximately exact. With the information now gained, the work of another season would, it is believed, suffice to complete the delineation of the Cretaceous rocks of the northern part of Vancouver Island and its vicinity, much of the information gained in 1885 possessing a negative value, in showing in which parts of the region the Cretaceous rocks need not be looked for.

General results. The geological result of the season's work may therefore be described in general terms as an examination of the shores of Queen Charlotte Sound (exclusive of those of the long inlets which penetrate the mainland), of those of the northern extremity of Vancouver and adjacent islands, and of Quatsino Sound, together with all the main shore of the Strait of Georgia which had not previously been geologically mapped by Mr. Richardson, with the exception of a stretch of about forty-two miles, between Jarvis and Burrard inlets. With this exception, and that of the upper portions of the long inlets, the shores of the waters sepa-

rating Vancouver Island from the mainland, have now been examined geologically, the length of coast-line gone over in 1885 being, exclusive of minor indentations, about 958 miles.

A survey was also made of the shores of Nimpkish or Karmutzen Lake, in the interior of Vancouver Island, and much information of a general character as to possible routes and the nature of the country, was obtained, such as to render it possible to lay out future work for the completion of the survey of any given portion of the region.

Specimens collected.

The geological and other specimens collected have already been referred to in my preliminary report. The invertebrates obtained by dredging and otherwise, have since been worked up by Mr. J. F. Whiteaves, whose report on them is published in the Transactions of the Royal Society of Canada (Vol. IV., Sec. IV., p. 111), rendering it unnecessary to include a list of them in the present report. The total number of species enumerated by Mr. Whiteaves, is 185. Notes and descriptions also by Mr. Whiteaves, of the fossils collected, form Appendix I. to this report. A list of the plants, by Professor Macoun, forms Appendix II., the meteorological observations constituting Appendix III. A considerable amount of information was also incidentally obtained on the Kwakiool Indians of the northern part of Vancouver Island and its vicinity, but with the exception of a few remarks bearing on particular localities, and the Indian names of a number of places, given on the map, this is not included in the present report.

Appendices.

The existence of trustworthy charts of the shores examined, together with the published account of the coast in the Vancouver Pilot, render it unnecessary, in most cases, to describe its general features at length. Such short notes, as it has been deemed advisable to give, are therefore incorporated with those on the geological features of the same localities.

General Geology.

Geological resemblance of Vancouver and Queen Charlotte Islands.

The geological resemblance between the part of Vancouver Island which is here described, and the southern half of the Queen Charlotte Islands, is extremely close. This resemblance had previously been referred to by me in general terms, and was indeed to be expected, as the Queen Charlotte Islands and Vancouver Island form portions of a single axis of elevation, which here constitutes the western member of the Cordillera. The work now reported on has, however, shown that the similarity of the rock formations is so close as almost to amount to identity, and the general geological description given in my report on the Queen Charlotte Islands, of 1878–79, might be adopted, with little change, for the northern part of Vancouver Island. The greatest point of difference as between the two islands, is the consider-

able development of Tertiary rocks in the northern part of the Queen Charlotte group, while rocks of this age are, so far as known, very scantily represented on Vancouver Island, and scarcely seen in the northern half of the island which is now under review.

Great abundance of volcanic materials.

By far the greater part of the area of the northern portion of Vancouver Island is occupied by rocks of volcanic origin, which at first sight, and as judged by Eastern American analogies, might often be supposed to represent formations occupying a very low stage in the geological scale. These volcanic rocks, originally composed of minerals already crystalline, have since been subjected to metamorphism more or less intense, to which, in consequence of their composition, they have easily yielded, and now form, for the most part, rocks which might be spoken of as "traps" and "greenstones." These frequently show, locally, little or no evidence of their bedded character. Such rocks, however, when closely examined, and followed from point to point, are found to form portions of a stratified series of great thickness, which includes, besides the preponderant volcanic materials, certain argillites and limestones, holding Triassic fossils.

Their original character.

The greater part of this old volcanic series appears to have been built up of basaltic and trachytic lava flows, alternating with rough volcanic breccias and tuffs, largely composed of fragments derived from such flows. These rocks are now represented by hard amygdaloids and agglomerates of general dark greenish colours, though often greyish and sometimes purplish or reddish; by felsites, more or less porphyritic, and by hard, regularly stratified ash-beds, which, where the alteration has been most pronounced, are locally changed to hornblendic or micaceous schists.

Subsequent alterations.

A microscopical examination of a limited number of specimens of these volcanic rocks, selected as characteristic, shows that they may now be classed generally as diabases and felsites, with occasional examples of diorite. These have, however, been subjected to so much alteration subsequent to the first mineralogical changes, that the felspars are almost invariably much decomposed, and few of the other crystalline minerals are unaffected. It is to the development of various green minerals as alteration-products during this secondary change, that the characteristic tint of these altered volcanic rocks is largely due.

Lava flows.

It is worthy of remark, that in several somewhat widely separated localities, a few of which are specially noted in the sequel, the original 'ropy' structure, frequently found on the surface of modern lava beds, has been well preserved in these old volcanic rocks, notwithstanding their great alteration. This structure is, of course, now only clearly apparent where the surface of an old lava has been covered by

some ashy or calcareous material, which has subsequently been removed by weathering.

Irregular quartz masses. The rather frequent occurrence of disconnected flattened or lenticular masses of crystalline quartz, or quartz and felspar, in massive green diabase rocks, giving them a blotched appearance, was at first a somewhat puzzling phenomenon. These are not of the character of segregations from the enclosing rock, but would seem to represent the position of former cavities and interspaces in breccias, or the brecciated surfaces of lava-flows which have become filled with zeolitic or chalcedonic materials, which have subsequently passed into their present state during the metamorphism of the formation.

Associated limestones and argillites. In association with these volcanic rocks, limestones, argillites and quartzites occur, possibly at several different horizons, but one of these, which is of considerable thickness and great persistency, and possesses very distinctive characters, has now been recognized at a number of places, from the northern part of the Strait of Georgia round the north end of the island, and in Quatsino Sound. This intercalated zone is of considerable thickness, having been estimated at 2500 at one place on the north coast of the island, where it appeared to be fully displayed.* Massive limestones, which, when the strata are considerably altered, pass into marble, form its lower portion. The upper part of the limestone becomes interbedded with argillites in regular flaggy layers, and black, flaggy argillites, interbedded with quartzites, overlie these. Where the top of this argillite series is seen, it often holds tufaceous and fine agglomeritic beds, and is followed, in ascending order, by a great thickness of the altered volcanic rocks. In other localities, the limestone is found to become interbedded with volcanic materials beneath, and though no complete section of the entire series can be offered, it is quite clear, from observations made in a great number of places, that these sedimentary materials form an intercalation in the great volcanic series.

Evidence of age of these rocks. The importance of this fact is apparent, when it is stated that the only means of fixing the age of the entire series is afforded by the fossils obtained from the limestone and argillite intercalation. These occur chiefly in the argillites and in passage beds between these and the more massive limestones, and are referable to the so-called Alpine Trias. No fossils, except these of this age, have yet been found in association with this sub-Cretaceous series in the northern part of Vancouver Island, while the Triassic forms have been recognized in numerous localities. The evidence on which these rocks are, there-

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* A partial section of the same belt of rocks in Section Cove, Queen Charlotte Islands, showed a thickness of 1783 feet. Report of Progress Geol. Surv. Can., 1878-79, p. 55 B.

fore, coloured as Triassic on the map, is identical with that on which the reference of the precisely similar series of the Queen Charlotte Islands is based. It is quite possible, in both cases, that the lower portion of the series may include rocks of greater age than Triassic, and the association of Triassic and Carboniferous volcanic rocks in the southern part of the interior of British Columbia, lends a degree of probability to the conjecture that rocks of the Carboniferous period may form a portion of those here described. There is, however, no direct evidence of this, either in the northern part of Vancouver Island or in the Queen Charlotte Islands.

Rocks of southern Vancouver Island.

The rocks beneath those of Cretaceous age in the southern portion of Vancouver Island are likewise, in great part, altered volcanic materials, which are interbedded with limestones, and in some places with argillites. The conjecture that beds of Carboniferous age may occur together with those referable to the Trias, in the Queen Charlotte Islands and the northern part of Vancouver Island, is strengthened by the fact that the late Mr. J. Richardson obtained a few poorly preserved fossils from limestones interbedded with the altered volcanic rocks of the Ballinac Islands, between Nanaimo and Comox, and at Mount Mark, in the centre of Vancouver Island, between Qualicum and Alberni, which were supposed by Mr. Billings to be either Carboniferous or Permian, and probably the former.*

Rocks of interior of British Columbia.

Though an unconformity has been proved to exist in at least one place between the Triassic and Carboniferous volcanic rocks of the southern interior of the province,† no such break has yet been found in any part of the sub-Cretaceous series of Vancouver Island, and if rocks of both these periods actually occur there, they cannot at present be separated.

The series as a whole, indicates throughout a continuance or recurrence of volcanic phenomena on an enormous scale, and must be at least several thousand feet in thickness.

The Vancouver series.

As a convenient distinctive name for the whole, I shall employ the term *Vancouver Series*, including for the present under this name, not only the entire mass of volcanic materials which unconformably underlie the Cretaceous, but also the interbedded limestones and flaggy argillites and quartzites. This name may also be understood to include the similar beds of the Queen Charlotte Islands, as well as those of the southern part of Vancouver Island, to which it was originally applied by Dr. Selwyn in 1871. If this great mass of rocks should eventually prove separable into Triassic and Carboniferous portions, I would suggest the retention of the name Vancouver series for the former.

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* Reports of Progress Geol. Surv. Can., 1872-73, p. 54, and 1873-74, p. 98.

† Report of Progress Geol. Surv. Can, 1877-78, p. 171 B.

The beds of the Vancouver series are the oldest known to occur in the district here described and in the Queen Charlotte Islands, and are frequently found in contact with or resting upon granitic rocks. They have not, however, been deposited upon a granitic floor, as the granites are evidently later in date than the rocks of the Vancouver series, and nothing whatever is known of the character of the surface upon which its volcanic and other associated beds were originally formed. Subjacent granites.

The relations of the granites to the rocks of the Vancouver series is peculiar, and appears at first sight to be of a very anomalous character. The position of the exposed areas of granite, so far as determined, is shown upon the map, and it may be added that the granites there indicated, with the exception of certain isolated patches, form merely the south-western border of the great granitic region of the Coast Ranges of the mainland, which, wherever examined by myself or by Mr. Richardson, has been found to be almost entirely composed of granites or granitic rocks. The circumstances attending the line of junction of the granites with the rocks of the Vancouver series have been carefully examined at a great number of points. The granites near this line are usually charged with innumerable darker fragments of the Vancouver series, which, when in the immediate vicinity of the parent rocks, are angular and clearly marked, but at a greater distance become rounded and blurred in outline, and might then be mistaken for concretionary masses in the granite, into the substance of which they have been in process of being absorbed. The width of the belt characterized by these fragments is very variable, and where the plane of the present surface cuts that of the junction of the two classes of rock at an acute angle—as is often the case—it is considerable, frequently exceeding half a mile. In other cases, the fragments are scattered out into the granite for a few hundred feet only. It was in several instances found impossible to draw a distinct line between the granites and the Vancouver rocks, except on the assumption that this line should run where the two materials are blended in nearly equal proportions. The edge of the Vancouver series is also, for some distance from the contact, very generally shattered and penetrated by granitic spurs, or by felsite dykes, which probably represent the granites in a fine-grained state. Relation of granites to Vancouver series. Character of junction. Included fragments.

If the granite merely formed limited intrusive masses in the Vancouver rocks, no difficulty would be found in accounting for the above facts, but the circumstance that it appears everywhere to be the material upon which these rocks rest, and that it is, nevertheless, evidently of later date than these rocks, appears to call for some special explanation. The only explanation which Cause of peculiar relations observed.

appears satisfactorily to account for the appearances met with, is, that in consequence of upheaval and denudation we now have at the surface a plane which was at one time so deeply buried in the earth's crust that the rocks beneath it had become subject to granitic fusion or alteration. The present surface must, therefore, have been either covered to a very great depth by beds accumulated in regularly superposed layers, or the strata must have been heaped together by folding to such a depth that the lower parts of the whole were affected by such granitic fusion, which was gradually progressing upwards through the mass, incorporating the rocks of the Vancouver series as it went. It is clear that the granitic rocks beneath were in a plastic condition, not alone from the fact that they are found to penetrate the older series, but also from the evidence everywhere met with of the scattering out of fragments of the stratified rocks into the granites.

Upward progress of isothermal planes.

Heaping together of stratified rocks by folding.

It is further probable that it was rather by excessive folding together of the rocks than by the superposition of a great mass of horizontal deposits, that the thickness of the Vancouver series became so great as to bring its lower portions down below the plane of fusion. This is shown by the fact that in some places—notably in the vicinity of Blunden Harbour and Seymour Narrows—both the granites and the rocks of the Vancouver series have been subjected to great pressure in a horizontal direction, causing the fragments in the agglomerates to assume lenticular forms, and impressing a more or less distinctly schistose character upon them, while the dark included fragments in the granites have been squeezed out into sheets, giving the portions of these rocks which are characterized by an abundance of such fragments an almost gneissic lamination. At the time at which this effect was produced, the granites must still have been in a plastic state.

Much altered masses.

Isolated masses of the volcanic rocks which have been included in the granites, are occasionally found in a highly crystalline schistose state. In a few places within the granite area, distinctly gneissic rocks were noted. These may either be still more highly altered portions of the Vancouver series, or may be the result of a foliation superinduced in the granite itself. There is little or nothing to indicate that they represent remnants of any older distinctively gneissic formation.

Nature of granite.

As is fully stated in following pages, the granites are almost always hornblendic and generally grey in colour. They, however, in many places, hold so little quartz and so large a proportion of hornblende, that they become quite dark in colour and resemble diorites, with which indeed they may at times be classed. Though granitoid rocks, differing somewhat in composition, occasionally meet along pretty definite lines, they more frequently blend imperceptibly. It appears

highly probable that the locally character of the beds, passing into a state of granitic fusion, may account for such differences.*

Argillite zone

On the inner side of Vancouver Island, it may further be remarked that for a long stretch the flaggy argillites and quartzites are frequently directly in contact with the granitic rocks, rendering it probable that the refractory character of their materials has proved a sufficient barrier to the progress of the granitic change, which may, locally, have nearly reached its possible limit. On the same side of the island, in proximity to the granitic mass, the volcanic materials are much more highly altered than on the outer or west coast, where granitic rocks are rarely seen.

Bearing of facts on production of gneissic foliation elsewhere.

The relations here well exemplified by the contact of the Vancouver series with the subjacent, though newer, granites, precisely repeat those fully detailed by Mr. A. C. Lawson, in his report on the Huronian (Keewatin) and so-called Laurentian rocks of the Lake of the Woods. (Annual Report, Geological Survey of Canada, 1885, p. 61 cc, *et seq.*) I have myself described the subjacent granitoid gneisses of that particular region as Laurentian (Geology and Resources of the Forty-ninth parallel, 1875), but in view of the facts now brought to light there, and those here detailed, I am disposed to regard them as not properly referable to the Laurentian, but as foliated granites which have been produced by circumstances nearly identical with those which have affected the Vancouver series. In the Lake of the Woods region, such effects had ceased before the earliest Palæozoic sediments were laid down, while in the west, they occurred at some date between the close of the Triassic and the inauguration of the Cretaceous periods.

Cretaceous rocks.

The northward continuation of the Comox Cretaceous rocks, when fully worked out, will probably be found to correspond with the series already determined by Mr. Richardson in the southern part of the same field. Of the precise relationship of the presumably Cretaceous area on the north-east side of Malaspina Strait, in the absence of determinable fossils, nothing can at present be said. It is possible that these rocks may prove to be Tertiary, like those of Burrard Inlet.

Cretaceous of Vancouver and Queen Charlotte Islands.

In the northern part of Vancouver Island, the Cretaceous which still remains, appears to consist of outliers of a distinct and older basin, and may probably be regarded as having been originally continuous with that developed in the Queen Charlotte Islands. The Cretaceous rocks of Quatsino Sound, have so far afforded the best sections, and in these we appear to find represented the three higher members of the Cretaceous section of the Queen Charlotte Islands, as it exists in the vicin-

* Compare remarks by Dr. Selwyn on granites of Eastern Townships, Quebec. Report of Progress Geol. Sur. Can., 1880-82, p. 7A.

ity of Skidegate Inlet. Remarks as to the character and possible thickness of the beds of Quatsino, are given at length on a later page. In comparing these with the corresponding rocks of the Queen Charlotte Islands, it is probable that the thickness of the Quatsino beds is somewhat less, and that the conditions met with in the lower or coal-bearing portion of the series, are more distinctly littoral at Quatsino, sandstones and conglomeritic layers being relatively more important. The Cretaceous rocks which extend along the north-east shore of Vancouver Island, from Port McNeill to Beaver Harbor, may in part represent the lowest, or coal-bearing portion of the Quatsino section. A few fossil plants obtained from Beaver Harbour, are Middle Cretaceous, and possibly referable to a horizon near that of the lowest beds at Quatsino, but much larger collections since made at Port McNeill, which have not yet been worked up in detail, are regarded by Sir Wm. Dawson as distinctly newer than these, though possibly older than the Nanaimo and Comox Cretaceous floras. It is thus evident that we have not merely a single horizon to deal with along this part of the north-east coast. No trace of the lower subdivisions represented at Skidegate (D. and E.), has yet been found on Vancouver Island.

The relations of the Cretaceous rocks of the Queen Charlotte Islands and those of thenorthern part of Vancouver Island, as now understood, may be expressed as below, in tabular form:—

Table of Cretaceous series.

	QUEEN CHARLOTTE ISLANDS.	NORTHERN PART OF VANCOUVER ISLAND.
Upper Cretaceous	A. Upper shales and sandstones, 1500 feet.	Port McNeill beds (?) A. Upper shales.
Middle Cretaceous	B. Coarse conglomerates, 200 feet. C. Lower shales and sandstones, with coal, 5000 ft. D. Agglomerates, 3500 feet. E. Lower sandstones, 1000 feet?	B. Coarse conglomerates. C. Lower sandstones & shales, with coal. D. wanting. E. "

Character of deposits.

In the course of the examination of the Cretaceous rocks of the northern part on Vancouver Island, it has been found that these rest unconformably on a rough and irregular denudation-surface of the older rocks, and that they have filled pre-existing hollows and valleys in this surface during a prolonged period of more or less uniform progressive depression. Owing to this circumstance, the higher Cretaceous beds successively overlap the older rocks, and as the areas of these beds which have escaped subsequent denudation, are pro-

bably to a great extent those which have filled the deeper portions of the hollows, it follows that the actually outcropping edges of the beds rarely give a complete section of the entire thickness of the formation. Under such circumstances, the Cretaceous beds in contact with the older rocks can be expected to represent merely a succession of shore deposits, which may be very different from those of the central portions of the same basin, in which, other things being equal, there is a greater probability of finding thick and workable deposits of coal. It is thus of importance to keep this condition in view in any explorations which may be carried out in search of coal.

Of distinctively Tertiary rocks, the only recognized occurrence within the area here described, is the small volcanic patch of Eel Reef, in Port McNeill. **Tertiary.**

The conditions of deposit and periods of disturbance and mountain formation indicated by the rocks of the northern part of Vancouver Island, and probably also by those of its southern portion, are very similar to those already outlined in a former report for the Queen Charlotte Islands. In the Triassic, and possibly also in the earlier Carboniferous period, enormous quantities of volcanic materials were ejected and accumulated along this part of the Pacific border, the inclusion in which of limestones and argillaceous deposits represent quiescent intervals, some of which must have been of long duration. This was closed or followed by a period of flexure and disturbance, which must have affected principally a line nearly coincident with that of the actual Coast Range of the adjacent mainland of British Columbia, during which the granitic rocks of that range and its vicinity were either locally produced or forced up into their present relations with the stratified series. More evidence of disturbance and of marked unconformity at this epoch, is found in Vancouver Island than was observed in the Queen Charlotte Islands. A prolonged period, resulting in very extensive denudation, must next have supervened, and either in consequence of this alone or as the result of the combined effect of denudation and depression, the mountains produced along the line of the Coast Range of the mainland, must have been broken through or greatly reduced, since the Middle Cretaceous beds occur not only on the coast, but to the east of the axis of the ranges now bordering it. A movement in the sense of depression progressed during the entire Cretaceous period, but Vancouver Island may have remained a land area during the earlier part of this period, as no representatives of the earlier beds of the Cretaceous have yet been found on it. These, in the Queen Charlotte Islands, again indicate great volcanic activity. Subsequent to the Cretaceous period a second era of folding and moun- **Conditions of formation of rock-series.**

tain making occurred, which probably resulted in the re-elevation of the Coast Range, but acted even more violently along a line running through the western portions of Queen Charlotte and Vancouver Islands—a fact rendered evident by the crumpling and contortion of the Cretaceous strata in the vicinity of this line, while the same beds are relatively undisturbed both along the eastern shores of the Queen Charlotte Islands and the north-eastern coast of Vancouver Island. For the Tertiary period, the region here specially described gives no information, except such as is afforded by the denudation and planing down of the older deposits.

Glaciation

The main facts bearing on the glaciation of the region and on the character of its superficial deposits are given in a summarized form at the end of the present report.

Useful minerals.

Throughout the descriptive portion of the report, details are given respecting the minerals of economic importance; consisting chiefly of coal, iron-ore and copper, with marble, granite and other building stones. It is unnecessary separately to enumerate the various localities, as these are sufficiently indicated by the marginal notes.

Descriptive Geology.

Northern Part of the Strait of Georgia.

Cretaceous rocks of Nanaimo and Comox.

The Cretaceous coal-bearing rocks of Nanaimo and Comox, border the south-western shore of the Strait of Georgia, forming a belt of comparatively low rolling or hilly country, between the mountainous region of the interior of Vancouver Island and the coast. Though locally much disturbed and affected by folds and faults parallel to a general north-west and south-east direction, these Cretaceous rocks still preserve, to a great degree, their original relation to the wide depression now occupied by the Strait of Georgia, being largely of the character of littoral formations, such as conglomerates and sandstones, to which category, in a certain sense, the coals also may be added. Series of shaly strata, intercalated with these, and holding truly marine fossils, indicate periods of greater depression, but the fact remains that many of the beds were laid down, along a sea-margin nearly at the level of the present coast. There is thus every reason for the belief that the Cretaceous strata underlie a great part of the actual Strait of Georgia, a belief which is strengthened by Mr. Richardson's observations of certain small patches of these rocks on the shores of Texada and Lasqueti Islands, on the north-east side of the strait. It is probable, however, that the rocks maintain their coal-bearing character, with greater regularity, in a direction parallel to the present and former coast-line,

than they would be found to do, if it were possible to follow them far beneath the waters of the strait, where more exclusively marine conditions might be expected to obtain. The somewhat variable character of the Cretaceous from point to point, is shown by the fact that Mr. Richardson found it necessary to adopt a different series of subdivisions for the measures of the Nanaimo and Comox regions, though these occupy the same general strike, and only fail in being continuous by the existence of a few miles of coast near Nanoose Harbour, on which the older underlying rocks occur. Coal-bearing character.

From reports received, and also from the flat appearance of the southern extremity of Valdez Island, and of Cortez, Mary, Savary, Hernando and Harwood islands, it was supposed that the Cretaceous coal-bearing series might have an important development in the northern and north-eastern part of the Strait of Georgia, or on the shore of the mainland in the vicinity. To determine this point, and also to learn something of the north-westward continuation of the Cretaceous rocks of Comox district, and the character, and bearing on this question of the outlying Cretaceous patches, of Texada and Lasqueti islands, already referred to, a systematic examination of the coast was begun at Comox. This was carried northward to Seymour Narrows, eastward by Cortez and the Redonda Islands to Malaspina Inlet and Strait, and included the whole of the shores of Texada and Lasqueti Islands. The results of this examinaton will now be given in such detail as appears necessary, in the order just stated. Variability of section.

From Comox wharf, the shore, turning eastward, forms a remarkable headland at a distance of about four miles,* which is named Cape Lazo on the chart, or in Mr. Richardson's reports, Point Holmes.† Mr. Richardson's detailed examination of the coast extended for some miles to the north-west of Cape Lazo. The coast sections at Comox wharf, and to Cape Lazo, show only boulder-clay and other drift deposits, and these, forming scarped bluffs, constitute conspicuous landmarks. From Cape Lazo north-westward, the coast was carefully examined, but for about eighteen miles, not a single exposure of solid rock was found; low bluffs of the drift deposits only diversifying the otherwise wooded banks which rise above high-tide mark. The shore itself is low and sandy, or gravelly, with wide flats bare at low-tide, and is strewn with numerous and large boulders. The first rock in place was seen at the distance above stated from Cape Lazo, in the middle of a wide shallow sinuosity of the coast known as Oyster Bay. Exposures here North-east border of basin. Comox to Oyster Bay.

* Nautical miles, measured on the Admiralty charts, are used in expressing distances throughout this report.

† The first-mentioned name undoubtedly has the priority. It occurs on Elsa's map (1791) as Pta. de Lazo de la Vega, though on the map accompanying Grant's paper (Jour. Royal Geog. Soc. 1857) and on other maps, it is shown as Point Holmes.

Oyster Bay.

occur frequently, for about four miles, or to Willow Point, nearly opposite Cape Mudge, and extensive surfaces and reefs of rock are laid bare at low-tide. The rocks are Cretaceous sandstones, of yellowish- and greenish-grey colours, sometimes soft and becoming rather shaly, and often nodularly hardened by calcareous matter, pale in colour and very compact, but weathering to pitted surfaces. No conglomerates were seen, though occasional layers holding a few pebbles occur in the sandstones. At the place first mentioned, in the centre of Oyster Bay, the sandstones form a low rocky cliff above the beach, but they generally appear only between tide-marks. A short distance further northward, about a mile south of Shelter Point, which forms the northern point of Oyster Bay, the sandstones were observed to dip S. 31° W. $<$ 25°,* but this dip is probably exceptionally high, as elsewhere the inclination does not exceed ten degrees, and is generally less than five degrees in amount. The beds lie in low, wide undulations, with no well-marked or persistent direction of strike, and the total thickness of strata shown along this part of the shore, must be quite inconsiderable.

North-western limit of basin on coast.

Some miles further to the north-west, nearly opposite the Yaculta village of the chart, (Tsa-kwa-loo'-in) is a low bluff, partly overgrown with grass, and bearing traces of having been formerly inhabited by the Indians. This, at first sight, appeared to be composed of conglomerate, but on examination proved to be merely drift or raised beach-gravel, cemented by calcareous matter. With this exception, the shore from the vicinity of Willow Point to Orange Point (a distance of over six miles) is low, and no rock exposures occur. At Orange Point, the old trappean rocks, which are known to underlie the Cretaceous unconformably, appear, consisting here of a massive looking, greyish-green diabase with epidotic veins, in which no stratification was clearly observable.

Extent of Comox basin.

The information afforded by the sections along the coast from Comox to Orange Point is, therefore, very meagre, but the exposures seen, together with the relatively low and uniform character of the country for several miles inland, leave it scarcely doubtful that the Cretaceous rocks here form a continuous belt, and confirm Mr. Richardson's conjecture that these rocks extend from Comox as far as Cape Mudge. Between the Comox River and the Campbell River (two miles south of Orange Point) the streams reaching the coast are very inconsiderable in size, the greater part of the region draining southward by the Comox (Courtenay) River. I was, however, informed that some miles up a small stream, which debouches about half a mile southward from Kuhushan Point of the chart, coal has been found. A coal

* This, with other bearings throughout the report, is given with reference to the astronomical meridian. The magnetic variation is here 23° 15′ East.

seam is also reported by Mr. Drabble about a day's journey up the Campbell River, while sandstones are seen in the banks of the river, from near its mouth, a long way up.

Horizon.

The Cretaceous rocks seen along the coast south of Orange Point rather resemble those of Mr. Richardson's lowest division, the "Productive measures," than those of the overlying "Lower shales," to one of which divisions they are probably referable.*

Probable inland continuation.

Beyond Seymour Narrows, the coast of Vancouver Island makes a projection to the north-eastward, and from the occurrence of sandstone and coal on the Campbell River, together with the general strike of the Cretaceous rocks, I have little doubt that these continue inland in a north-westward direction, leaving the coast near Orange Point and running behind the promontory just alluded to, possibly as far as the Salmon River, about thirty-five miles distant. On this stream, Mr. King, who has prospected the region for timber, reports that at about four miles above the forks of the river, or nine miles from its mouth, sandstones appear, and characterize a considerable tract of country of a lumpy or hilly character. The same gentleman informed me that sandstone again appears not far up the course of a considerable stream which empties into Menzies Bay, near Seymour Narrows.

Value of Comox coal-field.

To properly explore and map out the Cretaceous, coal-bearing rocks forming the north-western extension of those seen in the vicinity of Comox, it would be necessary to traverse all the larger streams, and though this is a work requiring some time and labour, on account of the generally thickly wooded and impassable nature of the country, it is one of importance, and should be undertaken, if possible, at an early date. In Mr. Richardson's opinion, the Comox coal-basin, though at present at a disadvantage owing to its somewhat greater distance from markets, is relatively more important than that of Nanaimo. The last section of the coal-bearing rocks examined by him to the north-westward, was that on Brown's River, nearly abreast of Cape Lazo. He there found the lower member of the Cretaceous series, designated by him the Productive Measures, to have a thickness of 739 feet, and to contain nine seams of coal, varying in thickness from six inches to seven feet. There is every reason to hope that the measures may continue equally rich in coal in their extension to the north-westward. If this should prove to be the case, even as far only as the Campbell River, a length of twenty-five miles will be added to the known portion of the Comox coal-basin, and this without taking into consideration the probable extension inland toward the Salmon River, above referred to. It is, however, to be anticipated, that boring operations,

* See Mr. Richardson's observations in Reports of Progress Geol. Surv., Can., 1872-73 and 1876-77.

Exploration by boring necessary.

on a somewhat extensive scale will be necessary, before this north-western part of the basin is fully proved, as the covering of drift materials is almost everywhere deep.

Vancouver series on Discovery Passage.

From Orange Point, above mentioned, the altered volcanic or trappean rocks (referred in a general way, as elsewhere stated, to the Triassic and provisionally designated the Vancouver series) are almost continuously exposed along the west side of Discovery Passage to Seymour Narrows, and along the east side from the Narrows southward to within two miles of the extremity of Cape Mudge. In this part of Discovery Passage, these rocks are generally amygdaloidal in character, but have, in many places, been so much changed by subsequent action, that this character has almost disappeared, together with all traces of the original bedding. Wherever the dip may still be distinguished, however, it appears to be at rather low angles. Most of these rocks show spots and veinlets of epidote of secondary formation, and they are generally greenish or greenish-grey in colour, though occasionally purplish. Copper Cliffs, of the chart, are composed of greenish and blackish altered amygdaloid, and show copper staining along jointage planes in some places. Steep Island, at the mouth of Gowland Harbour, is composed of massive beds of coarse agglomerate, many of the fragments in which are of amygdaloid. Copper stains also appear here. The dip is apparently N. 63° E. $< 30°$.

Lithological character of rocks.

A few typical specimens of the altered volcanic rocks of the Vancouver series, from the vicinity of Discovery Passage, have been subjected to a preliminary microscopic examination, with the following results:—

No. 6. Orange Point, Discovery Passage.—Dark grey-green diabase, considerably decomposed, but appears to have been originally an amygdaloid.

No. 7. Discovery Passage.—Amygdaloidal diabase, of which the cavities are generally filled by quartz. Reddish in colour as the result of the peroxidation of contained iron during decomposition. Contains little chlorite.

No. 8. Steep Island, Discovery Passage.—Greenish-grey amygdaloidal diorite, considerably decomposed, and amygdules filled by quartz.

No. 127. Discovery Passage, near Elk Bay.—Blackish-green glossy schistose rock, collected near line of junction of Vancouver series and granite. This is evidently a fragmental rock, and may be classed as a volcanic ash, being chiefly composed of felspar, much decomposed, and with abundance of chloritic matter.

No. 128. Discovery Passage.—Coarse greenish-grey agglomerate, a much decomposed diabase in which a minute concretionary structure is developed.

The southern extremity of Cape Mudge resembles Point Lazo in general appearance, and is like that point entirely composed of drift materials, including boulder-clay, which overlies stratified sandy deposits. The water shoals gradually, and wide flats covered with boulders are laid bare at low tide, a circumstance almost always, in this region, found to characterize a coast-line formed of boulder-clay or other drift materials. The same character is continued along the east side of the Cape Mudge promontory, northward as far as Drew Harbour. It is possible that Cretaceous rocks may underlie the southern extremity of the Cape Mudge promontory, but there is no evidence of this, and the older volcanic rocks have now been traced southward so far along the west side, that but two miles of the extremity of the cape remains, under which they might occur. **Cape Mudge.**

Drew Harbor is an excellent anchorage, sheltered on the east side by a low sandy and gravelly spit over a mile in length. It has been utilized lately as a logging camp, and considerable quantities of timber have been cut in parts of Valdez Island, adjacent to it. **Drew Harbour.**

The Strait of Georgia may be described as terminated to the northward by Valdez, Read and Cortez islands, which are separated by comparatively narrow passages, the first-named consisting, however, in reality of several islands separated by subsidiary channels, which have not been surveyed, and are scarcely navigable, on account of their rocky character and the very strong tides which run through them. **North end of Strait of Georgia.**

Forming a disconnected fringe of comparatively low, flat land to the southward of these islands, is the promontory of Cape Mudge, Mary Island, Reef Point of Cortez Island, with Hernando, Savåry and Harwood islands, the three last-named lying close to the shore of the mainland to the eastward. With the exception of the low land thus designated, the islands closing the Strait of Georgia to the north, are almost uniformily rocky, with rough, irregular surfaces, the average height of the elevations on which increase eastward toward the base of the Coast Range, and become high mountains along the sides of the fiords which penetrate far into the mainland. The fundamental and most prevalent rock is granitic, and is usually a hornblendic granite, rich in triclinic felspar, varying much in texture, but usually greyish in tint; one variety merging by imperceptible gradations with another. Included in these granites, or resting upon them, are areas more or less considerable, of altered volcanic rocks, associated with occasional argillites and limetones, the whole referable to the Vancouver series. **Low islands.** **Higher rocky islands.**

Having premised these general facts, such local details as seem important, will now be given for the region, the actual boundaries of the rock-series being indicated on the accompanying map. The stratified materials of volcanic origin, are, in the following pages, generally

designated as the altered volcanic rocks, the question of their geological age having been already discussed. (See p. 9 B.)

Vicinity of Drew Harbour.

The rocks of the shore west and north-west of Drew Harbour have the same appearance and character with those of Discovery Passage, already described, and are altered volcanic materials. To the north of Drew Harbour, however, just east of Open Bay, crystalline limestone appears in association with these rocks, and is cut off to the eastward by granitic rocks which show in places more or less gneissic foliation. What is probably a continuation of the same limestone band appears again, at less than a mile to the south-eastward, in the little rocky islets named the Breton Islands on the chart. The limestone is here, however, interstratified with grey and blackish thin-bedded argillites and quartzites, the strike of the whole being S. 47° E., with dips at very high angles, but generally south-westward. These beds are cut by dykes of highly quartzose, slightly hornblendic, granite, and are all much shattered, with rusty joints.

Hoskyn Inlet.

Hoskyn Inlet, which separates the Valdez Islands from Read Island, running north-north-eastward for nearly nine miles, was examined by my assistant, Mr. D. B. Dowling. It is narrow, and is bounded throughout by rough, rocky shores, composed of granitic rocks of the usual character. An opening, known as Surge Narrows, occurs on the west side of the inlet, and runs toward Discovery Passage through the Valdez group, with, possibly, a branch opening toward the north-east. Surge Narrows is partly blocked by several small, rocky islands, between which the tide runs with great velocity, resembling the rapids on some large river. The only spots which might be used as land for settlement are at the head of Village Bay and at the old Indian camp at the Narrows.

Read Island.

The highest land on Read Island is near its north end, and has an elevation, according to the chart, of 1608 feet. The south-east side of the island is throughout composed of massive, hornblendic granite, which varies from a fine-grained, dark-grey material to a pale whitish rock regularly spotted by rather large black crystals of mica and hornblende. Dark greyish-green dykes, probably diabase, intersect these rocks in all directions, and in some cases are so numerous as to form nearly one-third of the entire mass. The northern part of the east end of the island was not particularly examined, but appeared, from a distance, to be composed of similar crystalline rocks.

Cortez Island.

Cortez Island is, in the main, a tract of rough, rocky land, resembling Read Island in its general character. It is very irregular in form, and has a length of about fourteen miles from north to south, with a maximum breadth of about eight miles. The north-eastern portion of the island, which is nearly separated from the rest by a

long, narrow lagoon, appears to be throughout composed of hornblendic granites, the hornblende in some parts of which is rather of a greenish than a black colour. On Lewis Arm, some portions of this rock scarcely contain any visible quartz, while others hold numerous fine-grained, dark and more highly hornblendic masses, which may be fragmental or concretionary. Dark-colored dykes, resembling those already described on Read Island, are numerous locally. The north-east side of the main part of Cortez Island is everywhere formed of similar granitic rocks, with, in some places, numerous dark-coloured intrusions. At the point just east of Carrington Bay, an obscure appearance of stratification occurs, with a strike of about N. 27° W., and small quantities of molybdenite were found in quartz veins. On the small islands named Camp Islands, the granitic rocks were observed to be much broken up and silicified by action subsequent to their formation, which has produced numerous little masses of crystalline, iron pyrites and of epidote, which, however, do not occupy true veins. **Molybdenite.**

With the exception of Reef Point, which is composed of drift deposits, the entire south-west shore of Cortez Island, with Gorge Harbour, is composed of similar granitic rocks, containing more or less hornblende, and offering no peculiarities worthy of special note. On the east side, a mile from the south point, is a rather fine-grained greenish rock, which is much shattered and traversed by epidotic veins, and has an apparent dip of N. 55° E. $<$ 60°, and is probably a highly altered remnant of the Vancouver series. North of this, the granitic rocks resume, but continue to hold numerous fragments of a similar material. For about two miles south from the entrance to Squirrel Cove, the shore is bordered by a low terrace, composed of sand and gravel deposits, and heavily wooded. The flat land thus formed, however, appears to be quite limited in width. Near the entrance to Squirrel Cove, on the west side, are extensive exposures of coarse-grained, pale-coloured hornblendic granite, suitable for building-stone, and moderately well situated for quarrying. Squirrel Cove is a good, though small harbour, with an old Indian village site at its northern extremity, and a narrow, stony passage opening to the lagoon previously mentioned, which might be passable for small boats at very high tides. Just west of Squirrel Cove, on the outer shore, the granite was observed to assume reddish tints, though without otherwise changing its general character. Deer were moderately abundant on Cortez Island, and a limited number of sheep might be pastured on it. **South-west shore of Cortez Island.** **Building stone.**

The Twins, two small islands to the south of Cortez Island, are chiefly composed of the usual hornblendic granite, which is, however, **Twin Islands.**

in part reddish in colour. The east shore of the southern island, three quarters of a mile in length, is interesting, as displaying stratified rocks, consisting of dark slaty argillites, quartzite and limestone. These are all much broken and contorted, but in one place were observed to strike N. 57° W. They may be considered, with little doubt, as representing the continuation of similar stratified rocks met with on the north part of Hernando Island, and described on a subsequent page.

Redonda Islands.

The Redonda Islands, two in number, are very irregular in form. They are high and mountainous for the most part, a point on the inner or eastern island attaining 5140 feet, and several summits on the western island rising about 3000 feet. These islands may in fact be considered as a portion cut out of the general outline of the coast, by the two passages which converge and unite to form the fiord known as Toba Inlet, and as such, represent a part of the outer portion of the Coast Range. The western island is twelve and a half, the eastern, nine miles in length. The north side of West Redonda Island, is entirely composed of grey, hornblendic granite, generally notably coarse in grain, and occasionally porphyritic, and in some places, holding dark, highly hornblendic portions, a foot or more in diameter. The shore is uniformily bold and composed of solid rock, the only beach being in Deceit Bay, of the chart. Raza Island and the part of the mainland which forms the north shore of Pryce Passage, though not touched on, are evidently composed of rocks similar to these just described. Dean Point, the extreme north-eastern termination of the island, is peculiar in showing a rather highly quartzose granite, which contains very little hornblende. At Welsh Cove, a mile south of the last, on the east side of the island, the granite becomes distinctly pinkish in tint, and consists of two felspars, one probably orthoclase, the other triclinic, of pink and white colours respectively, with black mica, a little hornblende and abundance of quartz. This stone is well adapted for building purposes, and in Welsh Cove is favourably situated for quarrying, as it is traversed by nearly horizontal jointage-planes and rises in a low cliff from the water's edge. Near Dean Point and Welsh Cove, dark dykes, which were scarcely seen along the north shore, again become somewhat abundant. Further south, on the east shore, the rocks are in some places much darker in colour and more hornblendic, though still coarsely crystalline. In such rocks, quartz is almost or entirely absent, and they are either syenites or diorites. It is impossible, however, to separate the rocks of this character from the paler coloured and more quartzose varieties, with which they frequently blend by insensible degrees.

West Redonda Island.

Building stone.

At Marylebone Point, the south-eastern corner of West Redonda

Island, is a small inlet, shown on the chart in dotted lines. It is about half a mile in length only, and receives a stream at its head which, at a distance of about two hundred yards, was found to issue from a lake which is a mile or more in length and about twenty feet only above high-water mark.

Marylebone Point.

In the inlet just referred to, and about Marylebone Point, a greenish dioritic material is so irregularly mingled with paler granite of the usual character, that it is impossible to say which should be regarded as an intrusion in the other, each constituting about half the mass.

The south-east shore of West Redonda Island, on Desolation Sound, presents no features worthy of special mention, being composed of similar hornblendic granites. At one place, a considerable number of blackish diabase dykes were observed with a north-westward run. At another, near 'White Patch' of the chart, distinct traces of copper occur, forming green stains on weathered joints. Martin Island and Kinghorn Island, show only the same rocks. The west side of East Redonda Island was landed on at one point only, but is also evidently composed of similar rocks. East Redonda Island, as seen along Waddington Channel, and doubtless throughout its extent, is composed of granitoid rocks. It was not, however, particularly examined.

East Redonda Island.

Cape Mudge, Mary Island and Reef Point, with Hernando, Savary, and Harwood islands, have already been described as differing altogether in character from most of the land to the north and north-east of the Strait of Georgia. They may originally have formed a connected border of low terrace-land, with a maximum elevation of about 200 feet above the present sea-level. With small exceptions, they are entirely composed of drift deposits, consisting of boulder-clay, with bedded sands and gravels, some points in connection with which are more fully described under the head of surface geology. Though in general wooded, there are on these islands patches of meadow-land, which is often covered with bracken, and the woods are not so dense and impenetrable as elsewhere. The soil is usually, if not in all cases, rather light and sandy, but a considerable portion of these low lands might be utilized for purposes of agriculture.

Border of low lands and islands.

Mary Island has an area of about 2200 acres, and no exposures of rock in place occur on it. Its southern extremity is prolonged by a long bouldery reef, while its northern is formed by a sand spit, which nearly reaches to Cortez Island. The area of the flat land which forms Reef Point is about 2300 acres, and it terminates similarly, southward, in a wide, bouldery flat, partly bare at low tide.

Mary Island.

The area of Hernando Island is about 2200 acres. Stag Bay, on its north side, affords a good anchorage, and its north-eastern shore, for about a mile in length, is composed of rock. The south-eastern

Hernando Island.

exposures consist of massive crystalline rocks, probably dioritic, and differing from the more abundant hornblendic granites. Hidalgo Point, adjoining the last, is formed of stratified materials, much indurated and shattered by pale felspathic dykes, but consisting of rather thin-bedded, blackish argillites and quartzites, in some of which impressions of ammonitoid shells were found. These Mr. Whiteaves, in the Appendix, provisionally describes under the name *Belonites Vancouverensis*. The prevalent dip is about N. 55° E. $< 40°$.

Fossils.

Savary Island.

Savary Island, lies nearly east and west, and is about four miles long, but quite narrow. Its south side is formed by cliffs, and steep scarped banks of boulder-clay and stratified sands, the opposite or northern side being lower. Its total area is about 1200 acres, the soil being very light and sandy. Like the islands previously described, it presents wide, flat, boulder-strewn beaches, many of the boulders reaching a diameter of ten or even twenty feet. The extreme east end of the island, is formed by a steep but rounded mass of coarse, spotted, hornblendic granite, cut by dark dykes of diabase or diorite.

Harwood Island.

Harwood Island, with an area of about 1900 acres, scarcely differs from those above described. It is composed, for the most part, of well stratified sands and hard silty deposits, resembling those met with below the boulder-clay on Savary Island. The southern point of the island is composed of a rather fine-grained, grey, hornblendic granite, very much jointed. The lowest side of this island is toward the south, where there is some open land, covered with bracken. Elsewhere, the shore is generally bordered by bold, high banks, which are, however, as a rule, grass-grown, and do not present the same striking appearance as those of Savary Island.

Mitlenatch Island.

Mitlenatch Island, an isolated rock, 200 feet in height and half a mile in diameter, which lies in the middle of the strait, three miles east of Hernando Island, is composed of altered volcanic rocks, chiefly a grey-green massive amygdaloid, in which the cavities have been filled by quartz. These rocks are much jointed, and assume rugged forms where exposed to the action of the sea. The direction of their dip could scarcely be ascertained, though it appeared to be about S. 12° E. $< 10°$. The island has been heavily glaciated in a direction from north-west to south-east.

No Cretaceous rocks observed.

From the above notes, it will be apparent that no rocks of the Cretaceous, coal-bearing series occur in the islands bordering the north and north-east part of the Strait of Georgia, though these were specially looked for. Should such rocks occur there, they must occupy hollows between the projecting masses of the old crystalline rocks, and are now either covered by the waters of the strait or concealed by the drift deposits.

Malaspina Inlet and Vicinity.

The observations made in Malaspina Inlet, and along the shore of the mainland from Desolation Sound to Jarvis Inlet, may now be summarized, after which, those referring to Texada and Lasqueti islands will be given.

Malaspina Inlet runs about eight miles south-eastward, parallel to the shore of the Strait of Georgia, but separated from it by a promontory about two miles wide. The inlet itself is about half a mile in average width, and throws off an irregular branch to the eastward—Lancelot Arm—about three and a half miles in length. The rocks forming the shores of the main inlet belong entirely to the granitic series, but are rather peculiar in the paucity of quartz, which in some places is almost entirely absent, causing the rock to be more properly named a syenite or diorite than a hornblendic granite. The rocks are usually grey in general colour, but in some places dark greenish-grey. They hold often many darker masses of a fragmental appearance, and it was also here observed that they were frequently reticulated by pale lines, dependent on the bleaching of the rock by some subsequent action along the planes of jointage. **Malaspina Inlet.**

On the eastern extension of the inlet, the shores are generally formed of rocks similar to those above described, which, though probably in some places diorite in composition, preserve a granitic appearance, and by the addition of quartz and mica pass into true granites. In Theodosia Arm, which is entered from Lancelot Arm by a narrow passage, these rocks were observed to possess a slight appearance of bedding or foliation, and between Martin and Ellen Points of the chart, on the north side (just west of the entrance to Theodosia Arm), a small mass of stratified rocks appears, surrounded on all sides by those of a granitoid character. These consist of a grey and white spotted marble, in which kernels and veinlets of pale green serpentine have been developed, with some blackish, hard argillites with rutsy joints. The dip and strike are very irregular, but the former appeared to average N. 8° E. $< 70°$. These rocks occupy the shore for about 200 feet only. They show traces of copper, and similar traces were again seen nearly opposite Thynne Island of the chart, on the west side of Lancelot Arm. **Marble with serpentine.**

Though generally low, the shores of Malaspina Inlet are almost everywhere of solid rock, with small beaches showing only here and there in sheltered angles. The main inlet is continued southward by a low valley, and Theodosia Arm ends westward in a shallow flat, beyond which, low country extends for some distance. There is a **Character of shores.**

considerable quantity of very fair timber in the vicinity of the inlet generally, and probably a large area in the flat land beyond the head of Theodosia Arm. As coal had been reported to occur on this inlet, it was closely examined, but no trace of Cretaceous or Tertiary rocks was found. Though it is still possible that coal-bearing rocks may occur in the low tract just referred to, no drift material was observed which might indicate their existence.

Report of coal.

Entrance of Malaspina Inlet.

About the entrance to Malaspina Inlet, there is a considerable area of greenish granitoid rocks, some of which may be diorites, and, by their fine grain and much fractured appearance, suggest the possibility that they may represent the last stage in alteration of stratified rocks belonging to the volcanic series. They are occasionally associated with crumbling red syenite. The shores of the large bay east of the entrance of Malaspina Inlet, together with the south shore of Mink Island, lying off it, are characterized by granitic rocks which present no unusual characters.

Reddened granites.

Georgina and Sarah Points, to the west of the entrance, are composed of red syenite or hornblendic granite, while the intervening shore is generally occupied by the usual grey variety. The red rock appears here, and elsewhere in this vicinity, to be merely an altered variety of the grey, in which, in consequence of some action subsequent to its formation, the iron has become peroxidized. The texture and grain of both rocks is the same, and they are similarly blotched by darker included masses, which in the red variety are at times still blackish, but have also occasionally become reddened. The red rock is always much shattered and jointed, a circumstance probably connected with the change it has suffered. Its broken character renders it quite unfit for use, as a building stone.

Coast from Sarah Point to Jarvis Inlet.

Sarah Point to Ragged Islands.

From Sarah Point, to a point opposite the south end of the Ragged Islands, the rocks are partly reddish, like these last described, but chiefly grey in colour, and hornblendic granites, which in some places appear, from the absence of quartz, to become diorites. They are much shattered, and cut by numerous dark-coloured dykes, and some pale syenitic ones, and include very numerous irregular or lenticular fragments of a darker colour, such as are almost always found when the granitoid rocks approach the borders of stratified masses. The fragments are in some places so abundant, that from their arrangement, they cause the rock to assume a gneissic appearance, the strike being in general nearly parallel to the shore. On the inner side, and near the south end of the Ragged Islands, a small area of distinctly

stratified hornblendic gneiss, with fine-grained mica-schist, occurs. These rocks are much broken and very irregular, but the general dip is about N. 47° E. $< 60°$. Powell Islets and White Island, further off shore, are composed of the usual grey granitoid rocks, and scarcely any soil is found upon them.

Coast south of Ragged Islands. From the Ragged Islands southward, for a distance of five miles, or to a point nearly abreast of the southern termination of Malaspina Inlet, the coast continues very bold, and is composed everywhere of solid rock. The prevalent materials are grey hornblendic granites, of the usual massive character, which in some places have assumed a red tint, in the manner previously explained. **Included stratified masses.** Distinctly stratified rocks were observed in two places. The first of these is just south of Hirtuda Point, and opposite the east end of Savary Island. The rocks seem to be diorites and felsites, but are so much shattered and rust stained as to be almost past recognition. The strike appears to be nearly north and south, but the shore is characterized by these rocks for about 300 feet only. The second occurrence is two miles further southward and is much more important, occupying the shore for three-quarters of a mile. **Marble.** It includes a bed of grey marble, about fifty feet in thickness, and nearly vertical, with a strike of about N. 20° W. The marble is associated and interstratified with dark greyish and greenish speckled rocks, which are so completely shattered, that but for the marble, their stratified character could scarcely be recognised. These rocks have not been specially examined, but their mineral constituents are much decomposed. They are either diorites or diabases, and appear to represent the last stage in metamorphism of stratified volcanic rocks, like those of Discovery Passage.

Low shores. South of this point, to the Klahoos Indian village in the bay abreast of Harwood Island, the shore is much less bold, and the rock appears in isolated low exposures only. It is either hornblendic granite or diorite, of granitoid texture, wherever seen. The long low gravelly beaches, which characterize this part of the coast, are not indicated on the chart, and indeed the representation of the smaller features of the coast, from Sarah Point southward to Jarvis Inlet, is very imperfect. Notably wide tide-flats, strewn with large boulders, occur along the coast about half way between Savary and Harwood islands.

Vicinity of Klahoos village. The south point of the shallow, open bay, in which the Indian village above referred to is situated, is formed of a boss of rather coarse granitoid rock, containing much hornblende and little or no quartz, which is cut by dark diabase dykes of the usual character. Half a mile southward, in the next bay, is the mouth of a small river, which flows from a lake at a distance of about a mile and a half from the shore. This lake is reported to be very large and to run a long way

Powell Lake and River.

to the northward. Its form is conjecturally indicated, and it is named Powell Lake on the map published by the Chief Commissioner of Lands and Works of British Columbia (1884), and the river may be designated by the same name. From views of the country in this vicinity, obtained from the strait, the lake would appear to occupy a rather narrow valley between high hills, and it is doubtless orographically identical with many of the salt-water inlets. Three-quarters of a mile from the mouth of the river is a rapid and fall, the stream here being confined between high, rocky banks, and well adapted for use as a water-power. The stream averages 150 feet in width by three feet deep. Its valley is nearly impassable from fallen timber and a stiff, intervening growth of sal-lal bushes, and, finding the rocks all of the usual granitic character, I did not take time to penetrate as far as the lake. The height of the river above the fall and rapid is about fifty feet above sea-level.

Water-power.

Powell River to Grief Point.

Southward, to within a couple of miles of Scotch-fir Point, at the entrance of Jarvis Inlet, the coast is low, and a low and apparently everywhere densely wooded country stretches some miles inland, and will, doubtless, afford a large quantity of valuable timber. From the mouth of Powell River to Grief Point, due east from the north end of Texada Island, there are no rock exposures along the shore. Grief Point itself is low and flat, but half a mile to the south-east of it, a bluff about eighty feet in height affords a section of the drift deposits, by which a considerable part of the low country is probably underlain. These resemble those of Savary and other neighbouring islands, being composed of finely stratified hard sands, overlain by about fifteen feet of stony clay, which probably represents the boulder-clay.

Grief Point to Sandstone River.

Six miles eastward along the north shore of Malaspina Strait from Grief Point, is the mouth of Sandstone River, of which some particulars are given below. On the intervening coast, rock *in situ* appears in three places only, as follows:—Two miles east of Grief Point, forming a low bluff; blackish, spotted hornblende-schist with some grey felsite, both cut by numerous veinlets of epidote and quartz. Strike, S. 87° E., nearly vertical. Islets, in the same little bay, of similar rocks, with fine and coarse-grained diorite. Point just west of mouth of Sandstone River, with low exposures of grey hornblendic granite. East of the river, low exposures of rather coarse hornblendic granite are more frequent, and before Scotch-fir Point is reached they become almost continuous, but offer nothing worthy of special note.

Sandstone River.

The Sandstone River is a small stream, and at the date of my visit (July 1885) was about twenty feet wide only, with an average depth of about nine inches. Its bed presents almost continuous exposures of sandstones and shales, for about a mile and a half up from its mouth.

The sandstones are soft, of yellowish and brownish colours, often coarse, and in places slightly conglomeritic; the shales are blackish or greenish-grey. The beds are almost horizontal, the highest dip probably not exceeding 5°, and the total thickness of beds exposed cannot be more than about 200 feet. Flattened stems and logs, included in the sandstones, are in the form of lignite, but no true bed of coal or lignite is exposed. A few fossil plants which were obtained are very imperfectly preserved, and insufficient to show whether these beds should be classed as Cretaceous or Tertiary. Further up the river, the banks become quite low, and show only occasional small exposures of drift materials, the current is slack, and there appeared to be no prospect of obtaining further information as to the width of the sandstone series. It may, however, underlie a considerable part of the low country of this part of the coast. Coal or lignite.

In a small stream about a mile east of Sandstone River, the Indians report the existence of similar rocks at a short distance from its mouth. No exposures of sandstone, however, appear along the coast, and it would seem that the low bosses of granite there occurring have served to protect the sandstone rocks in an inland basin. Before the exact limits of this sandstone basin can be mapped, it will be necessary to traverse the whole of the thickly wooded, low country near the coast from Jarvis Inlet to the Klahoos Indian village, the Indians inhabiting which were quite averse to giving any information or assistance respecting the region at the date of our visit. Area of sandstones.

The rocks of Jarvis Inlet, for a distance of about six miles up, were examined by Mr. Dowling, who reports them to consist of hornblendic granite, but in general, of paler tints than usual. Near the south-east point of Hardy Island, is a small area of included schistose rocks, and in the vicinity of the small bay on the south side of the island, near its west end, it was observed that the granite is favourably situated for quarrying, and well adapted for building-stone. Jarvis Inlet. Building-stone.

From the mouth of Jarvis Inlet to Burrard Inlet, the coast has not yet been examined geologically. As seen from the sea, it is evidently for the most part granitic, but there are low wooded areas in some places, and Cretaceous and Tertiary rocks may not improbably be found in these, particularly in the vicinity of Trail Islands, and about Thormanby Island. Coast south of Jarvis Inlet.

Texada Island.

Texada Island, so named by Elsa, in 1791, is nearly twenty-seven miles in length, with an extreme breadth of but five and a half miles. The island is high and mountainous throughout, and very rocky, offering scarcely any land suitable for agriculture. The shores are very Geological character of the island.

bold, beaches of gravel or sand being quite exceptional, though narrow boulder-beaches are more common. The island may, in fact, be regarded as a partially submerged mountain range or ridge, and by reason of its narrow form, when seen from the Strait of Georgia to the south-eastward, resembles a single high mountain mass. It is in general, wooded, and some very fair timber is to be found in the valleys, but bare rocky hill-sides are everywhere frequent. The forest is, however, generally not dense, particularly on the south-eastern side of the island, where the climate must be relatively dry. Deer are generally abundant on the island, and it will doubtless eventually be utilized for the pasturage of sheep. It is singularly deficient in harbours, in comparison with other parts of the coast—Gillies Bay, on the south-west side, and a second bay at the northern extremity, being the only two of any value, and both somewhat exposed to certain winds.

Mr. James Richardson's explanations.

The geological features of a portion of the island were examined by the late Mr. Jas. Richardson, and are described by him in the Reports of Progress of the Geological Survey, for 1873–74 and 1876–77. My own examination of the island, in 1885, was confined almost exclusively to the shores, but included a careful inspection of every part of the coast-line, it being specially desirable to ascertain the existence or otherwise of any rocks of the Cretaceous coal-bearing series which might there occur. With the exception of the Cretaceous area of Gillies Bay, discovered by Mr. Richardson, it may now be affirmed, that no rocks of this age appear on the island.

General geological character.

Texada Island is composed, for the most part, of the rocks of the Vancouver series, and chiefly of altered volcanic materials. These are, however, traversed by somewhat important granitic masses, particularly on the north-east shore; while the northern extremity of the island, for a length of about five miles, is largely composed of more or less crystalline limestone, which is frequently a true marble. Deposits of copper, marble and magnetic iron-ore have been located on the island, and work undertaken on them, though the last mentioned mineral is the only one of which the exploration has attained any considerable importance. So far as the stratigraphical features go, there is no reason to believe that the altered volcanic rocks, and the massive limestones, represent distinct formations, and the palæontological evidence is almost nil, consisting of a few obscure molluscs obtained from the less altered parts of the limestone about a mile south of Point Marshall, at the north end of the island. The association and interbedding of volcanic rocks with the marbles of the northern part of the island, and the intercalation of these limestone beds with those of the southern portion, indicate the close relationship in time of the two classes of rock, which—even apart from the facts afforded by similar

association elsewhere—renders it necessary for the present, at least, to regard the whole as forming one great series.

Bed of marble. At the base of Mount Dick of the chart, on the east shore, near the southern extreme of the island, is a small broken and shattered anticlinal, including a bed of purplish, pinkish and variegated marble, with a maximum thickness of about twenty feet. This is interbedded with greenish, rubbly, felspathic rocks, in association with which are some dark-coloured, earthy, calcareous shales. The marble is too much affected by joints to be of any value. **Coast from Point Upwood to North-east Point.** Point Upwood, and the southern end of the island in its vicinity, is composed of hard, massive, greyish and greenish-grey rocks, many of which, though much altered, are still evident agglomerates, and show their fragmental character on weathered surfaces.

On rounding the south-east point of the island, well stratified greenish and grey felspathic and hornblendic schistose rocks are met with, presenting a ribboned appearance on weathered surfaces. They are not far from vertical in attitude, and the strike, which is fairly regular, nearly coincides with the coast, causing the same rocks to characterize it for several miles northwards. These rocks are closely associated with agglomerate and ash rocks, which sometimes replace them on the shore, and eventually preponderate, and occupy the coast to the exclusion of other materials, to a point nine miles north of the south point. Thence, for three miles, the only rocks seen along the shore are grey hornblendic granites of coarse or medium grain. Beyond these, greenish, bluish and grey rocks, composed of altered volcanic materials, again appear, and occupy the shore to a place abreast of Scotch-fir Point. These rocks are here even more completely altered and hardened than usual, being traversed by numerous dykes of dark greenstone and some of granite, while small segregated granite masses also occur in them. They are extremely shattered, and jointage-planes coloured by copper, were observed in several places. The appearance of these rocks is such as to lead to the belief that they form but a narrow border on the coast, and are backed by and in contact with granite on the landward side. At North-east Point of the chart, and for nearly two miles southward from it, the shore is again occupied by granitic rocks, which, near their junction with the volcanic series, hold numerous dark fragments, as is usual at such junctions.

Ash-rock. A specimen of a dark grey, rather fine-grained, massive rock, from a point a mile and a half north of the south end of the island, proved on microscopical examination to be an evident altered ash rock. It is chiefly composed of broken felspar grains, with a few of quartz, and much chloritic matter subsequently developed. Rocks of identical

appearance to this one, macroscopically, are very abundant both on Texada and Lasqueti islands.

Iron ore beyond North-east Point.

For four miles north-westward from North-east Point, there are alternations of granite with volcanic rocks, as shown on the accompanying map, but no new features are presented. At the place thus defined, a little cove, with a small, abandoned frame house, occurs. The granites here again indicate their approach to the stratified rocks by the number of included dark fragments, and are replaced by them beyond the north point of the cove. The Vancouver rocks are here made up of dark green hornblendic and epidotic materials, and include a bed of marble, in association with which is a considerable deposit of magnetic iron-ore, details of which are given on a later page, in connection with those of other similar deposits of the island.

Marbles.

Beyond the above occurrence of iron ore, the shore is occupied for about a mile by marble, associated with some greenish amygdaloidal rocks. The marble varies from nearly white to grey and blotched varieties, and forms cliffs of from fifty to eighty feet in height. The dip averages about south-south-west, or inland, at high angles. Granite next appears for about half a mile, but near the entrance to Marble Cove, it is again replaced by marble. Near the northern edge of the granite, where that rock is in contact with the marble, it assumes a somewhat unusual appearance, being almost entirely composed of quartz and white felspar. It is here traversed by a vein of copper ore, on which some work has been done, a drift of about sixty feet having been run in on the vein in a direction of S. 38° W. The vein, as seen at the mouth of the drift, is about eighteen inches wide, and is still visible in the roof where the work stopped, though turning off a little in a southerly direction. Several tons of ore, remaining on the dump, appear to be of fairly good quality, consisting of mixed copper and iron pyrites (the latter often in large crystalline cubes) in a gangue of calcite and quartz, with andradite, tremolite, chlorite and molybdenite as accessory minerals. The work has not been carried sufficiently far to warrant any definite opinion on the character or continuity of the deposit. Endeavours should be made to trace it by uncovering the surface, rather than by further drifting. A small building has been erected near the drift, which is situated about 200 yards from the shore, near the base of a steeply sloping hill.

Copper ore.

Assay.

On assay by Mr. Hoffmann, the ore from this locality proved to contain, in addition to copper, 10·20 ounces of silver to the ton. The specimen submitted to analysis consisted of about 55 per cent. metallic sulphides, the remainder gangue.

Marble quarry at Marble Cove.

Marble forms the shores of Marble Cove, with the exception of the north point, where granite occurs, apparently as a dyke running

inland in a westward direction. From this cove, with unimportant local exceptions, marble is found continuously along the shore to the north end of the island. A small marble quarry has been opened at the north side of the cove, this place having probably been selected as affording a shelter to small vessels. Trial shipments of the marble have been made to Victoria, and several large and good looking blocks still remain at the quarry. It would appear, however, that the site chosen for the quarry is not a very good one, as the stone is there more affected than usual by jointage-cracks, and is not so well coloured as at some other points. Attention might with advantage be directed to the marble cliffs previously described, about a mile and a half south-eastward from the cove, or to the exposures north of the cove. These places, though not affording harbours, are only rarely exposed to any heavy sea, and the water is generally so bold that barges or schooners might be laid up almost to the shore while loading.

Marble Cove and north end of island.

From Marble Cove to the north point, the marble, though often much disturbed and traversed by dykes, generally dips southward at rather low angles. At the north point it is vertical, with a strike of S. 10° E. The shores of the bay, at the north end of the island, with Marshall Point west of it, are also chiefly composed of marble or limestone, more or less distinctly crystalline. The dip is very irregular in direction and amount. The rock is much jointed, and traversed by numerous greenish felspathic and blackish diabase dykes. Similar conditions continue, for about a mile and a half south, along the west shore, till the exposures are interrupted in a wide bay, beyond which the limestones are not again seen. Rebecca Island, a small rocky patch lying off Point Marshall, is composed of greenish felspathic rocks and highly crystalline marble, and evidently constitutes a detached portion of the Texada Island mass. The general form assumed by the marbles and associated rocks of the northern part of Texada Island, is that of a synclinal.

Rebecca Island.

Marshall Point to Gillies Bay.

Southward, from the last limestone exposures, to within ten miles of Gillies Bay, hard greenish and grey much altered amygdaloids occupy the shore, till replaced near the point above defined (at which the houses of the Texada Iron Mine are situated) by agglomerates. These volcanic rocks evidently underlie the limestones, and at the mine are abruptly cut off by a granitic mass, half a mile in width on the shore. This rock closely resembles that seen near the copper deposit, on the opposite side of the island. The wharf of the Texada Iron Mine, is situated about a quarter of a mile south-east of the houses, at the foot of the slope. The line of junction of the granitic with the volcanic series, presents the characters commonly found under such circumstances, the volcanic rocks being not only much hardened, but

shattered and penetrated by granitic dykes, while both rocks show scattered segregations of iron pyrites.

Texada iron mine.

The principal deposit of ore, from which a considerable quantity has been shipped, but on which operations were practically suspended at the time of my visit, in 1885, is situated about quarter of a mile inland from the wharf, and at a height of probably about 250 feet from the sea, on the brow of a steep rocky hill. The arrangements for mining and shipping the ore are complete. Shoots at the head of the wharf, receive the ore from trucks, at the bottom of the slope, which is substantially laid and well ironed, and is provided with a double track, the full trucks in descending drawing up the empties. From the level of the drum at the head of the slope, the track runs a short distance round the eastern flank of the hill, to the place at which the ore is at present being quarried. A drift, which has been run into the side of the hill, was closed and could not be examined. A very large quantity of ore is at present in sight above the level of the track, and in advantageous positions for work.*

Mr. Richardson on Texada iron ore.

Mr. Richardson, who examined this deposit with some care before working had been attempted, describes it as follows:†—" On the south side of Texada Island, about three miles north-westerly from Gillies Bay, and about seventy paces from the shore, a small exposure of magnetic iron ore was met with, associated with a coarse-grained epidotic rock and grey diorite. Immediately north of this exposure, the ground rises steeply to about 450 feet above the sea. Here, on the eastern and south-eastern slopes of the hill, for about 150 feet down, and extending from 200 to 250 feet in length, is an exposure of rich magnetic iron-ore. On the outcrops, facing to the north-west, the ore-bed, which dips from S. 58° E. to $< 25°–30°$, is seen to be from twenty to twenty-five feet thick, and to rest on grey crystalline limestone, with which, for about two feet down, are interstratified bands of ore, of from half an inch to one inch in thickness. The hill still rises to the north and north-east, but along the flank, and at about the same elevation, in a north-westerly direction for nearly a mile, the ore is occasionally seen, and in one place there is a continuous exposure of it for about 250 feet, the bed apparently varying in thickness from one foot to ten feet. In the concealed intervals, its course appears to be indicated by a coarsely crystalline epidotic rock, carrying ore in places, but with the grey limestones apparently overlying it to the north-east, and the grey and green dioritic rocks beneath it to the

* Work was again resumed in the autumn of 1876, and during the winter about 5500 tons of ore was mined and shipped by the Puget Sound Iron Company to their works at Irondale, W.T. The Texada ore is generally mixed from 1-9 to 3-10 bog ore, found near Irondale, and produces thus, or when smelted alone, an excellent foundry pig.

† Report of Progress, Geol. Surv. Can., 1873-4, p 99.

south-west. Where the ore bed is exposed in this part of the hill, a similar arrangement of the beds is observed, and what here appears to be the base of the limestone, exhibits interstratifications of ore similar to those described at its summit, in the first exposure. An overturned dip is probably the cause of the apparent differences in the arrangement of the beds. In a north-easterly direction from the first noticed exposure, for a quarter of a mile, no ore is seen, after which it is again found, at first in irregular patches, mixed with epidotic rocks, and then, its course becoming more northerly, for more than half a mile, the bed presents an irregular surface exposure of from 600 to 900 feet of nearly pure ore. In this part, the dip could not be ascertained with certainty, and I am therefore unable to estimate the thickness of the ore. Loose pieces of limestone, with interstratified ore-bands, were found on the west side, while to the east, the ore is bounded by grey and green dioritic rocks."

I would modify the above description by Mr. Richardson in one main point only, namely, in respect to the nature of the ore-deposit. This appears to me to be neither a bed nor a true vein, but a contact-deposit which has been produced at or near the junction of the granitic mass with the stratified rocks, and more particularly with the limestone. Near the head of the slope, where the ore has been worked, the granitic rocks are replaced by grey crystalline limestone. which occasionally becomes a nearly white marble, and at this contact, the large bodies of ore are found, and appear to occupy irregular 'chimneys' or interspaces of very variable dimensions. The ore penetrates, to some extent, not only the granitic rocks, but also the altered volcanic rocks and the limestone. It frequently includes large or small epidotic kernels, together with detached fragments of the volcanic rocks, and, in some places, reticulated veins of ore are seen in the granite, forming a species of ore-breccia. The appearances are such as to indicate that the formation of the deposit occurred contemporaneously with the intrusion of the granitic mass, and has been dependent on the effects produced by that intrusion. Specimens of mixed ore and limestone, which may be collected, closely simulate interbedding, but the appearances developed since work has been carried on are such as, in my opinion, to prove that the ore cannot be considered a bedded deposit. Nature of the ore-deposit.

The first ore exposure mentioned by Mr. Richardson is probably one which has been cut through on the slope, between the wharf and its head. This is thirty feet or more in thickness, but is of inferior quality, and contains a considerable proportion of iron pyrites. The second exposure described is doubtless that at the head of the present slope. Portions of the ore in the actual workings are also found to Ore bodies.

contain more or less pyrites, and these are at present rejected as unfit for shipment. Traces of copper are also not infrequently seen on weathered jointage-planes in the mass of the iron ore.

Analyses of ore.

The quality of the greater part of the ore is excellent. A partial analysis by Dr. Harrington, in the laboratory of the Survey, showed 68·40 per cent. of iron, with only ·003 per cent. of phosphorus. In Volume XV: (Mining Industries) of the Tenth Census of the United States, p. 580, a partial analysis by Whitfield is given of a sample of this ore, selected as representing a lot of 600 tons at the Puget Sound Iron Company's furnaces. This shows—Iron, 65·71; phosphorus, ·013. A more detailed analysis, carried out by Messrs. P. C. Gilchrist and E. Riley, of specimens sent to the Colonial and Indian Exhibition in 1886, and published by these gentlemen in the Journal of the Iron and Steel Institute, 1886, p. 561, gave the following result:—

Iron	69·85
Manganese	trace.
Siliceous matter	2·75
Sulphur	·06
Phosphoric acid	trace.
Moisture	trace.

Further tracing and working of the ore.

The character of this ore, as a contact-deposit on the borders of the granite, indicates the importance of tracing out the junction of this rock with the stratified series, and particularly the advisability of closely examining and uncovering such contacts as occur between the granite and the limestone. So long as such deposits can be found in convenient proximity to the shipping point, it will be unnecessary to sink on them to any great depth, and the quantity of ore already known is not likely to be exhausted for many years. The deposit of similar ore, noted on the opposite side of the island, occurs under nearly identical circumstances. The same may be said respecting the copper ore previously described, and traces of either copper- or iron-pyrites were observed in several additional localities near such contacts in different parts of Texada, in which island indications of metalliferous deposits of this character are unusually abundant. It should be stated here that the outlines of the granite as shown on the map, are exact only where they come out on the shores; they are scarcely more than hypothetical in the interior, having been traced inland for an inconsiderable distance only in a few places. The information gained with respect to the position of the metalliferous deposits, should, however, serve as an important guide to further discoveries, the characters of the granitic and other rocks being sufficiently distinct for easy recognition.

A few words may now be added respecting the deposit of magnetite at the north-east side of the island. This, as has already been indicated, is situated on the shore of a shallow bay or cove, almost directly across the island from that last described and about five miles from the north point of the island. A bed of grey to white crystalline limestone or marble here occurs in association with hard, greenish, altered volcanic rocks of the usual character. The calcareous rock appears to form a bed of which the greatest observed thickness was about fifteen feet. It is, however, so much shattered and twisted as to render its thickness very irregular, but runs along the shore with a general strike of about S. 55° E. for 200 feet or further, generally maintaining a dip at an angle of 40° or more to the southward. That the calcareous material is a bed, is rendered evident by its blending and becoming interstratified with the greenish felspathic rocks, and also by the entire absence of any characteristic crystalline vein stuff. It is in some places quite free from magnetite, but is generally highly charged with that material, which, though forming in it very irregular masses of pure ore, has generally more or less of a stratiform arrangement, and is occasionally found minutely interlaminated with calcareous matter. The most important solid stratiform mass of magnetite seen is about four feet in thickness. Epidote, and in some places small quantities of quartz, occur in association with the ore, which, when the limestone is removed by weathering, generally forms black masses of pure magnetite of a scoriaceous appearance and very irregular in form. The beach is strewn with loose blocks derived, by this process of weathering, from the limestone, and the deposit has the appearance of being an important one, deserving attention so soon as the price of ore may justify mining operations. The contact of the limestones and volcanic rocks with the granite is close by to the south on the shore, and it appears probable that granite also occurs at the back of these rocks, not far inland.

Iron ore of east side of Texada Island.

Peculiar relations of magnetite and limestone.

A short distance southward from the wharf of the Texada iron mine, the shore loses its bold character. With the exception of the sandstones to be noticed immediately, no rock exposures are seen, and the beach is low and boulder-strewn to Shelter Point or Island, a distance of three and a half miles. The sandstones just alluded to are evidently of Cretaceous age, and indicate the existence of an outlier of that formation, representing a portion of the north-eastern edge of the Comox coal-basin, the greater part of which is concealed by the waters of the Strait of Gecrgia. This outlier was discovered by Mr. Richardson, and is noticed by him in the Report of Progress for 1876–77, p 169. Though the shores of the bay were examined by me at low tide, I could find but a single small outcrop of the sandstone in place, and this

Cretaceous outlier of Gillies Bay.

partly covered by boulders and gravel. The sandstone is grey in colour, but weathers brown, and forms rough honeycombed surfaces. It has a dip of about 5° in a direction S. 48° W., or directly seaward. It does not resemble the Cretaceous beds, subsequently described as having being found actually in contact with the older rocks on Lasqueti Island, but may nevertheless be not far from the local base of the Cretaceous series.

Extent and character of the outlier.

It is impossible to determine the actual extent of the Cretaceous outlier thus indicated, but as represented on the accompanying map, it is given its probable maximum size, and is somewhat larger than shown on Mr. Richardson's map. The low, level character of the land about Gillies Bay, appears to indicate that its area may be as great as shown. Mr. Richardson supposed the rocks to represent the lowest division or Productive measures of the Comox section, and though this must remain for the present uncertain, in consequence of the possible progressive overlap of the upper parts of the Cretaceous on the older rocks in this vicinity, it may eventually be desirable to set the question at rest by boring, as it is possible that a workable area of coal may occur in the outlier. The extremity of the point north of Gillies Bay, would be the most suitable place for such boring, but it should be stated that the surface of the older rocks is here evidently a very rough one, and that after having passed through the drift deposits at this point, these old rocks might be found directly to underlie them.

Coast south-east of Gillies Bay.

Shelter Island consists of grey-green altered volcanic rocks, chiefly a rather rough agglomerate, which is overlain by an amygdaloid. The dip is about S. 45° E. $<$ 25°. The remaining portion of the shore of Texada Island, to the south-eastward, is composed of greyish greenish, and bluish-grey, hard, altered volcanic rocks, chiefly or entirely agglomerates or amygdaloids, but in many places so much altered, as to be scarcely recognizable as such. They form, for the most part, a bold rocky shore, and a few small rocky islets lying off, are of the same materials. The strike is generally nearly parallel to the shore, with south-westward dips at angles of 15° to 30°. The cnly feature requiring special note, is the occurrence of a small bed of limestone, a few feet in thickness, about half a mile southward from the most prominent south-western point. This includes obscure traces of fossils. It rests upon the surface of a greyish amygdaloid, and is overlain by 'ropy' felspathic trap, which, as it resembles the upper surface of an old lava-flow, may indicate an inversion of the strata. The occurrence of the limestone in this accociation, may at least be accepted as an evidence of the submarine character of some of the eruptions which have produced this great series of volcanic rocks.

Interbedded limestone.

Lasqueti Island.

Lasqueti Island, separated from the southern part of Texada Island by Sabine Channel, contrasts markedly with that island in the much indented outline of its shores. Its surface is generally characterized by irregularly rounded, rocky hills, the highest of which attains an altitude, according to the chart, of 1056 feet. There are, however, some limited tracts susceptible of cultivation, near the shore, and two or three settlers have established themselves upon these, and have stocked the island with sheep. **General character.**

The island is composed, for the most part, of altered volcanic rocks, which are probably a repetition of those met with on the adjacent portion of the shore of Texada Island, Sabine Channel occupying an intervening synclinal. The strikes of the beds, on the sides of the channel, diverge to the north-westward, coinciding approximately in direction with the opposite shore lines. The northern portion of the island is chiefly composed of amygdaloids, while the southern is formed principally of agglomerates, which have, however, in many places, been so much altered as to require very close examination to detect their true character. Some compact trappean beds occur in association with the agglomerates, which have evidently been lava-flows, one of these, near Point Young, shows a fairly well marked columnar structure, and another, three-quarters of a mile north from the south-east point, on Bull Passage, affords an excellent example of the 'ropy' structure above alluded to. This peculiar structure was not infrequently observed in other places in connexion with the altered volcanic rocks, and is pretty evidently that of the surface of a lava-flow, resembling those found on Vesuvius and other recent volcanoes. The flow of the viscous or partly consolidated mass, has produced a confused aggregate of knotted, rounded and irregularly cylindrical forms of an involved character, and without distinct interspaces. The structure is not merely superficial, but affects a considerable mass of material, which in this instance, is now a bluish felspathic rock, not evidently amygdaloidal. The lithological characters of the other rocks of the altered volcanic series on Lasqueti, are so similar to those of the rocks of Texada as not to require special description. **Rocks of Vancouver series.** **Ropy structure.**

The head of False Bay, at the west end of the island, is occupied by a mass of granitic or syenitic rocks, of pale greyish tints, which shatter and penetrate the Vancouver rocks near the line of junction. The extension inland of this mass is not accurately known. **Granite.**

The most interesting geological point connected with Lasqueti Island, is the occurrence, on its shores, of small outliers of rocks of the **Cretaceous outliers.**

Cretaceous system. The more important of these were observed by Mr. Richardson, and are noticed by him, in general terms, in the Report of Progress for 1876–77 (p. 169.) The places at which the outliers occur are as follows:—1. Tucker Bay, small island in south-east angle; 2. Tucker Bay, south-west angle, behind a small point or peninsula (this outlier has an area of a few yards only); 3. Extremity of west point of Tucker Bay; 4. Island in bay west of Tucker Bay; 5. North point of Lasqueti Island, with two small islands to the east of it (this outlier has an aggregate area of about 250 acres, and is the largest); 6. West end of Lasqueti Island (a narrow border, along the shore opposite Flat Island, half a mile in length); 7. Inner side of Flat Island; 8. South shore of Lasqueti Island, half a mile east of Boat Cove; 9. Sangster Island, to the south of Lasqueti.

Jenkins Island, Bare Islands, and the Sisters, though surrounding Lasqueti to the west and south-west, are composed of altered volcanic rocks, the latter consisting of bluish-grey agglomerate, dip N. 45° E. $<$ 15°. The positions of the small Cretaceous outliers surrounding Lasqueti Island are shown on a special plan in the corner of the map which accompanies this report.

Character of lowest beds.

With the exception of places in which the lowest beds of the Cretaceous outliers follow undulations of the subjacent surface, these rocks dip uniformly off shore at low angles, varying from 0° to 15°, being in no case much greater than might be accounted for by the slope of the old shore-line on which they have been deposited. Where well exposed, the lowest beds of the Cretaceous are rough conglomerates, with coarse sandstones, the fragments consisting of the altered volcanic rocks, which give a greenish colour to the whole. The surface of the older rocks is often extremely rough and irregular, resembling portions of the present coast-line which has been much broken up by the waves, and the Cretaceous deposits are often found filling nearly vertical crevices in the older rocks with the appearance of a rough concrete which has been cemented by calcareous matter. These appearances are well seen at the small outlier numbered 3, at the west end of No. 5, the north end of No. 6, and at No. 7.

Large boulders.

The last mentioned locality is notable on account of the numerous large partly rounded blocks of the Vancouver rocks, which appear irregularly imbedded in the basal Cretaceous conglomerate. These seem to have been derived from neighbouring cliffs of the altered volcanic materials, and some of them are as much as fifteen feet in greatest diameter. At this place also, calcareous, serpula-like tubes, with portions of shells, were found still actually attached to the old rocks, and the whole appearance is that of a rough shore-line. Spines of an

Echinoid, and partially rounded fragments of thick-shelled molluscs, are moderately abundant in parts of these green basal Cretaceous conglomerates. These include a *Terebratella*, apparently an undescribed species; an *Ostrea*, a *Pecten*, and a cast of an *Opis* like *O. Vancouverensis* of the Productive measures. The most common and characteristic fossil is, however, a species of nullipore, which frequently forms a considerable portion of the mass. A second form, with coarser structure, may also be a nullipore, but much resembles a fine-grained coral-like *Solenopora*. These are found, not only in detached pieces, but in small encrusting masses, on stones included in the conglomerate. Calcareous Polyzoa and other organic fragments are also seen to be abundant under the microscope. Fossils.

Overlying the conglomerates above described, or in some places resting without their intervention on the surface of the older rocks, are grey, brown-weathering sandstones, with conglomeritic layers, holding well-rounded pebbles, quite different from the sub-angular material of the basal beds. The greatest thickness of Cretaceous rocks appears in the outlier at the north end of Lasqueti Island, and is about 260 feet, the higher beds much resembling those previously described at Gillies Bay, Texada Island. Sandstones.

The questions raised by the occurrence of these littoral Cretaceous beds are very interesting, but can here only be touched on. They are identical with the basal beds described by Mr. Richardson, and afterwards examined by me, on the north shore of Departure Bay, east of the coal wharves.* They also resemble those noticed by Mr. Richardson, but which I have not seen, on North-west Bay.† The amount of disturbance which the Cretaceous rocks have suffered in both the Nanaimo and Comox areas, is too great to allow us to assume that these littoral deposits—thus rather widely spread, but in the cases above mentioned, always at the present sea-level—represent portions of a single contemporaneous Cretaceous shore. It must rather be assumed that they constitute parts of a shore deposit which has progressively overlapped the older rocks during a period of subsidence, and that the coal deposits of the Cretaceous rocks have been formed at times during which the deposition was in excess of the subsidence, or when the subsidence had temporarily ceased, allowing the formation and continued existence of land areas. This being the case, the littoral deposits in question need be accepted as marking any precise stage in the Cretaceous or as holding a definite relation in stratigraphical position to the coal-bearing horizons. Conditions of deposit.

Sangster Island, to the south of Lasqueti, was not visited by me. Sangster Island.

* Report of Progress Geol. Surv. Can., 1871-72, p. 81.
† Report of Progress, Geol. Surv. Can. 1876-77, p. 167.

It is described by Mr. Richardson as "wholly composed of sandstones and conglomerates, the latter being largely made up of rounded pebbles of white, yellow and greenish quartzite, ranging from half an inch to fifteen inches in diameter, together with other rounded pebbles of dioritic rocks. The pebbles are held in a matrix of greenish-brown sandstone."* It would appear from this description that the horizon of the rocks of Sangster Island may be nearly the same with that of the highest beds of the north point of Lasqueti Island. Should it ever be determined to test these outlying Cretaceous rocks by boring, with the view of determining the possible existence of coal, this island seems to be the most promising place for the attempt, though but little encouragement can be offered to such an experiment, as the total thickness of the measures would probably be found to be small, and the surface on which they rest is likely a very rough and irregular one.

Possible occurrence of coal.

Northern Part of Discovery Passage.

Distribution of granites and Vancouver series.

Discovery Passage, of which Seymour Narrows forms the most constricted portion, runs north beyond the Narrows, with a few degrees of westing, for twelve miles. The west shore for ten miles northward, the east for six miles,—or to the southern point of the wide inlet which penetrates Valdez Island—are formed of the rocks of the Vancouver series; the northern parts of both shores being of granitic rocks. The line separating the two classes of rocks runs south-eastward, crossing the strait very obliquely, and continuing toward the eastern shore of Valdez Island, where it has already been noted north of Drew Harbour (p. 22 B). The general strike of the Vancouver rocks is about north-north-west by south-south-east, or nearly parallel to the direction of the line separating these rocks from the granites. The strike is, however, irregular in detail, and in many places the rocks are so massive as to afford no information as to their attitude. For about three miles along the west shore, near Elk Bay, the rocks are greenish schists, passing into schistose agglomerates, in which the fragments have been squeezed into lenticular forms, and in a few places approaching ordinary argillites in appearance, and probably in composition. The southern part of the west shore is chiefly occupied by greenish, altered agglomerates, in which the constituent fragments can sometimes be made out only on weathered surfaces. Three and two-third miles south of Otter Point, a quartz vein about two feet wide, holding a little copper pyrites, was observed cutting these rocks.

Copper ore.

* Report of Progress 1876-77, p. 169.

On the east side of the passage, the rocks about Plumper and Deep-water bays, and those of Separation Head, are amygdaloids of green and pale greyish-green colours, very distinctly stratified in massive beds, and dipping at rather low variable angles. These rocks, in some places, show the peculiar 'ropy' structure which has already been noticed (p. 41 B). Paler, apparently concretionary, and more highly epidotic portions produce an irregular blotching on some surfaces, and in certain layers, very irregular, flattened mas es, chiefly composed of crystalline quartz, are plentifully distributed. These were frequently seen in certain beds of the altered volcanic rocks. They appear, as already explained, to represent original cavities or interspaces in the slaggy surfaces of lava-flows which have been filled by subsequent percolation with chalcedony or zeolitic minerals, and finally altered to their present state during the metamorphism of the rocks. Amygdaloids. Quartz blotches.

The granitic rocks appear on the west side of the passage, a mile and a quarter south of Otter Cove. A small isolated area of the altered volcanic rocks then occurs on the shore. It is shattered, and penetrated in all directions by granitic and felspathic dykes. The granite near the junction of the two classes of rocks, is characterized by the usual abundance of dark included fragments. It presents exactly the same appearance at its contact with the altered volcanic rocks further south, on the east side of the passage. The granite is of the usual grey colour, and contains hornblende in greater or less abundance. It varies slightly in texture and composition, and dark greenish-grey diabase dykes are found cutting it in some places. In Otter Cove, the granite has a pale pinkish tinge, and contains a white triclinic felspar, with a pink orthoclase. The grain is uniform and the stone free from injurious jointage-planes. It is moderately easy to dress and work, and takes a a good polish, and might be quarried to advantage on the island in the mouth of the cove, or elsewhere around its shores. Chatham Point, to the north of the cove, shows a highly hornblendic and darker coloured variety of granite. Margin of granite. Building-stone.

Some notes on the microscopic character of the altered volcanic rocks of Discovery Passage are given on page 20 B.

Johnstone Strait, and Islands and Channels to the Northward.

Johnstone Strait runs, from Chatham Point, with a remarkably direct course of about west-north-west, for fifty-four miles, the western extremity of the strait being assumed to be at Beaver Cove. The strait has an average width of about a mile at its eastern end, but gradually widens, till it averages nearly two miles in width at its western extremity. The south shore is, throughout, formed by Van- Johnstone Strait.

couver Island, and is singularly bold and even in outline. Beaches of any kind are quite rare, the only ones of any importance being at the mouths of Salmon and Adams rivers of the chart. This bold shore is backed by abrupt mountains, which generally rise with steep wooded slopes from the water's edge and form an almost connected chain, which, on the charts, is named in different parts of its length from east to west, Halifax Range, Prince of Wales Range, Newcastle Range and Franklin Range. The northern side of the strait is formed by the Thurlow Islands, Hardwicke Island, two projecting promontaries of the mainland, and Cracroft Island, between which open channels and passages, leading to Phillips Arm, Loughborough Inlet and Knight Inlet. Though nearly in all cases rocky and bold, the northern shores of the strait do not exhibit mountains so high as these bordering the south or Vancouver Island shore, though farther north, toward the heads of the larger fiords, mountains of equal and greater height are found, the altitudes of the higher peaks increasing with considerable regularity as the axis of the Coast Range is approached.

Depth and origin. Johnstone Strait has not been fully examined as to depth, but like most of the fiords in this region, it is very deep, many soundings given on the chart at depths greater than one hundred fathoms, not having reached bottom. It is probable that a median channel at least one hundred fathoms in depth, could be traced throughout the greater part of its length. Its whole appearance suggests that it may have originated as an old river-valley, which has received at one time the drainage of the mainland to the north, by a number of streams, of which it carried the united waters toward the hollow now occupied by Queen Charlotte Sound.

Nature of examination. Following the plan adopted in the Strait of Georgia, both shores of Johnstone Strait were geologically examined, together with the adjacent islands and water-ways, but the longer fiords, which penetrate the coast of the mainland, and a number of connecting passages, in which there appeared to be no reasonable probability of the occurrence of the Cretaceous coal-bearing rocks, were left for subsequent investigation.

Having in the preceding pages described at some length the character, appearance and relations of the fundamental granitic rocks of the region, with those of the superposed Vancouver group, it may now be sufficient, without entering into detail except in special cases, to summarize the facts observed, the distribution of the two series being shown on the accompanying map.

South shore. Granitic areas. The examination of the Vancouver shore of Johnstone Strait, was carried out by my assistant, Mr. Dowling, from whose notes it appears that granitic rocks characterize it from Chatham Point westward, for nine and a half miles. These rocks here present no unusual character,

and where they meet with the altered volcanic rocks of the Vancouver series, become spotted by dark, included fragments, in the manner commonly observed near such junctions. A second area of similar rocks appears on the south shore of the strait, opposite the entrance of Port Neville, and occupies the coast to and beyond Adams River, a distance of eight miles. From the appearance of the mountains inland, and the abundance of included fragments (which are not usually observed in the granite very far from its edge) it is probable that this granitic area constitutes a rather narrow border along the coast. The granites here contain, as a rule, about the usual proportion of hornblende, but in some cases pass into a rock which might be classed as a granitoid diorite.

With the above exceptions, the entire south coast of Johnstone Strait is formed of rocks of the volcanic portion of the Vancouver series. The strike of these is in general not far from parallel to the shore, with prevalent dips in a southward or south-westward direction. This fact is evidenced, not alone by the observed attitude of beds, but also by the recurrence of rocks in different places along the shore which exhibit peculiarities so well marked, that there is every reason to infer the repetition at several points of a single bed. The altered volcanic rocks present the usual dark greenish and greenish-black colours in most places, and consist of agglomerates and amygdaloids, closely resembling those of Discovery Passage, which, it is to be observed, are in nearly the same line of strike. The resemblance of these rocks is so close to those of Discovery Passage, as to suggest identity of horizon with that of the rocks of that place, which have been noted already in some detail. Concretionary beds, or beds showing the 'ropy' flow structure, are marked features in some places. **South shore. Vancouver series.**

The south side of East Thurlow Island, forming the north shore of Johnstone Strait at its east end, together with the western shores of Nodales Channel and the Pendar Islands are formed of granitic rocks of the usual character, but here, and on the opposite side of Johnstone Strait, west of Chatham Point, there is a marked abundance of a highly hornblendic, dark coloured granite, which in some cases appears to blend with a pinkish granite like that of Otter Cove (p. 45 B), in other cases meets it along jointage- or fault-planes, and in a few instances appeared to be distinctly penetrated by dykes of the paler granite, both being, in turn, cut by dark, diabase dykes. **North shore. Thurlow Island.**

On the inner side of the small island nearly opposite Chatham Point to the north, a quarry might advantageously be opened, the stone resembling that of Otter Cove, and being favourably situated to work. **Building-stone.**

Of West Thurlow Island, eleven and a half miles in length, the whole **West Thurlow Island.**

shore was examined. It is composed almost entirely of grey, granitic rocks, which however, in places, become unusually dark in colour, and approach diorite in appearance, quartz being almost entirely absent. Mica was rarely observed as an important constituent. Included dark fragments, with their edges more or less distinctly angular, are abundant in many places, and at one locality, on the north shore, just south of Tucker Point, there are considerable exposures of granite, so regularly spotted by dark inclusions of this kind, as apparently to possess some value as an ornamental stone. Some of these inclusions still preserve angular outlines, and show adjacent faces of complimentary form, between which the granite has penetrated, while others are undefined in outline, and appear to be melting away in the granitic magma. A large specimen of the rock brought away from this locality, proved susceptible of a good polish, and the circumstances are such that a quarry might here be opened, if desired. The north side of Chancellor Channel, opposite to West Thurlow Island, is everywhere granitic, though it was not so closely examined.

Blotched granite.

At its west end, this island terminates in two points, the northern of these being named Eden Point. The end of this point, together with that to the south of it, and the south shore of the island for two and a half miles eastward, is composed of altered rocks of the Vancouver series, some of which are brecciated, and apparently altered agglomerates, but include also some well-bedded and much hardened dark argillites of a flaggy character. These rocks are all not only highly altered, but much disturbed and thrown about, and evidently form but a narrow border resting on the granites.

Agglomerates and argillites.

Further west, the rocks last described fringe the south shore of Hardwicke Island. About midway, between Eden Point and Helmcken Island, a small detached area of fine-grained dark rocks of dioritic aspect first appears, and is presumed to represent a much altered part of the stratified series. North of Helmcken Island, similar rocks, but here distinctly bedded, and striking about west-north-west, occupy the shore for about three-quarters of a mile. They are cut in all directions, by small, pale, felspathic dykes, which are doubtless connected with the granite, and may be regarded as a compact form of that material. Beyond a small interruption of grey granite, similar bedded rocks resume, and form the south-eastern shore for three and a half miles, together with York Island and a second small islet lying beyond it. The series here includes a considerable thickness of hard, flinty, flaggy argillites and quartzites, much fractured and jointed, and weathering rusty, with interbedded quartzites and materials of dioritic appearance. There are also thick masses of altered amygdaloid of the usual dark greenish colours. The angles of dip are high and irregular, but the strike runs

Hardwicke Island.

nearly parallel to the shore. The argillites and quartzites precisely reproduce the appearance of those of Hernando Island, in the Strait of Georgia (p. 26 B). Helmcken Island is composed of similar rocks, but was not closely examined.

Gneissic rocks.

The remainder, and greater part of Hardwicke Island, is occupied by granitic rocks, which in a few places assume an appearance of gneissic lamination, possibly indicating the bedding of rocks from which the granites themselves have been formed, but more probably referable to some species of superinduced foliation. The strike of the gneissic structure is very irregular, but where best developed, at the east end of the island, near the middle of Wellbore Channel, it is about N. 68° E., and nearly vertical. Traces of gneissic structure were found in a few other places in the region here described, but are quite rare and exceptional, a fact leading to the belief that they may be explicable in the manner above suggested.

Absence of drift deposits.

The almost complete absence of drift deposits or terraces, among these rocky, though wooded islands, cannot be better illustrated than by referring to the fact that traces of such deposits were found in two places only on the whole shores of Thurlow Islands and Hardwicke Island. One of these is at the east end of East Thurlow Island, near the entrance to Mayne Passage, where a small low terrace with scarped front was seen. The second locality is on Hardwicke Island, due north of the west end of Helmcken Island, where a terrace about fifty feet high occurs, formed of stratified sands, capped by gravels.

Coast west of Hardwicke Island.

Further to the west, the rocks of the Vancouver series form the southern part of the promontory which separates Blenkinsop Bay from Port Harvey, and with the exception of one small interruption of granite, occupy the coast for five and a quarter miles west of the entrance to Port Harvey. The relatively low and flat character of the promontory just referred to, led to the belief that it might be occupied by Cretaceous or newer rocks, but such did not prove to be the case. The line of junction between the stratified rocks and granites, beginning just within the western entrance point of Blenkinsop Bay, turns north-north-westward, and runs across to Port Neville. The southern shore of the promontory is occupied by greenish altered volcanic rocks, chiefly amygdaloids, while between these and the granites to the north-westward, is an extensive display of hard, flaggy argillites, of the usual character, which, so far as observed, dip north-north-eastward, at very high angles. The argillites are attached to the volcanic rocks, and interbedded with them about the junction, and both are much disturbed and cut by numerous grey felspathic dykes. On the west side of the entrance to Port Neville, similar rocks are again found, their strike turning to the south of west. They terminate in

Vancouver rocks.

a feather edge on the shore, at the distance above given west of the entrance, and where in immediate proximity to the granites, are much shattered and traversed by granitic dykes, and by segregation veins filled with the constituent minerals of the granites.

Granites.

The north shore of Sunderland Channel and shores of Blenkinsop Bay are formed of the usual grey hornblendic granite, cut by numerous greenstone dykes. Similar massive rocks form both shores of the entire upper portion of Port Neville, but in a few places on the north side, they become dioritic, and show the same appearances of gneissic foliation previously alluded to. The strike of the foliation is not discordant with the bedding of the altered volcanic rocks, the margin of which is found about a mile and a half south-westward. Similar rocks form the point which separates Johnstone Strait from Havannah Channel, and the Broken Islands lying off this point. At a place nearly a mile west of the point, on the south side of Havannah Channel, hornblendic and felspathic schists were observed to form a small area in the granite, with a strike of S. 30° W., and nearly vertical. These may represent an included mass of the Vancouver series, but are more highly altered and crystalline than usual.

Gneissic rocks.

Cracroft Island.

Cracroft Island, nineteen miles in length, forms the north shore of Johnstone Strait west of Havannah Channel. It decreases gradually in width westward, terminating in a long, narrow point. The south shore of the island, to the west side of Forward Bay, is composed of granitic rocks, with the exception of one place, nearly due west of Domville Point, where blackish and greenish dioritic schists appear for about one hundred yards, with a strike of N. 26° W. These are probably a continuation of the foliated or stratified crystalline rocks last described. On the west shore of Port Harvey, and elsewhere in this vicinity, grey hornblendic granite of good quality might easily be quarried in large blocks.

Building-stone.

The northern [shore of the eastern half of Cracroft Island was not examined. The whole western part of the island, from a line beginning just within the west entrance point of Forward Bay and running north-westward across it, is composed of rocks of the Vancouver series, and very largely of amygdaloidal rocks in heavy beds, which dip at rather low angles of inclination.

Hanson and Plumper Islands.

Hanson Island and the group of small islands at its west end, known as the Plumper Islands, are also entirely composed of rocks of the Vancouver series, comprising both amygdaloids and agglomerates, the whole with greenish, blackish, grey, and occasionally purplish tints. The strike of the rocks in these islands shows a distinct tendency to a general south-westward direction, with north-westward dips, often at low angles. In the bay at the east end of Hanson Island,

south of Burnt Point, a small, low reef was found to be composed of fine-grained grey limestone, of which the attitude could not be determined.

From the foregoing description of the rocks of the vicinity of Johnstone Strait, it will have been observed that this fine channel follows in a general way the line of junction of the Vancouver series with the underlying granitic rocks; the granites, nevertheless, forming two portions of the southern shore, and the stratified rocks occurring in a number of places with a greater or less width on its northern side, and entirely composing both shores for a length of about fifteen miles at its western extremity. The strait probably owes its existence to this geological feature, and there is a tendency, generally observable, to the formation of a hollow in the granites near their line of junction with the stratified rocks, giving evidence of a greater facility of erosion or decay in the granites at or near this line. A further important fact, brought out by the examination of this part of the coast, is the frequent recurrence and general continuity of the zone characterized by the flaggy argillites, in that part of the Vancouver series near the edge of the granites, and the independently observed parallelism, in a broad way, of the strikes of the bedded rocks with the line of junction. There is little room for doubt that the argillites hold a position well down in the generally volcanic series, and characterize a definite horizon, which can thus be traced from point to point, from Hernando Island in the Strait of Georgia to Queen Charlotte Sound, a total distance of about eighty-three miles.

General distribution of rocks, Johnstone Strait.

Argillite zone.

On reaching the eastern end of Queen Charlotte Sound, the northern border of the rocks of the Vancouver series sweeps round to the north, with an irregular edge, touching here and there upon the islands which fringe the sound. Before reaching the north side of the sound, however, their border again probably becomes coincident in direction with the general strike, and continues north-eastward, rarely infringing upon the granitic shore of the mainland. The greater part of the wide hollow now occupied by the waters of the sound is, doubtless, excavated in beds of the Vancouver series.

West end of Johnstone Strait.

Eastern Extremity and Northern Shore of Queen Charlotte Sound.

Before proceeding to note the character of the north-western part of Vancouver and adjacent islands, the observations made along the eastern and northern shores of Queen Charlotte Sound may be briefly summarized. The existence of the wide hollow occupied by the sound and the presence of Cretaceous, coal-bearing rocks on its southern shore, appeared to render it not improbable that these rocks might

extend in places to the east or north shores, but the most careful examination has failed to discover any trace of them on these shores.

Swanson and Harbledown Islands.

The southern and south-western parts of Swanson and Harbledown islands, with several smaller islands of the same group, are composed of rocks of the Vancouver series, while the northern parts of the two large islands, above named, with almost the whole of Lewis Island, and a number of smaller islets and rocks fringing them on the north, are granitic. The line between the two series is somewhat irregular, as shown on the map. The stratified rocks are here all extremely disturbed and irregular in attitude, being traversed by intrusive masses and dykes. This is particularly the case at the west end of Harbledown Island, the south-west point of which, and its south shore eastward for about two miles, is chiefly composed of dark, coarsely crystalline rocks, of dioritic appearance and evidently intrusive.

Flaggy argillites.

Notwithstanding this irregularity, however, a wide belt of splintery, flaggy argillites, with interbedded quartzites, can be traced from the north-west extremity of Swanson Island, in a south-eastward direction, across the two intervening small islands, to Harbledown Island, around the shores of Parson Bay, and again on the south shore of the island, where it includes beds of fine-grained, grey limestone. The argillites are associated with a considerable mass of greenish, altered volcanic rocks, in most places, and where the stratified rocks approach the granites, they become distinctly crystalline, often forming dark, blackish-green, hornblendic schists, as on the south-east part of the shore of Harbledown Island. On this shore, half a mile west of the extreme east point, is a somewhat extensive exposure of grey and variegated white-and-grey marble,

Marble.

which in places has apparently been broken up and re-cemented, having in the process included numerous fragments of the adjacent green, felspathic and hornblendic rocks. The relations of the bedded rocks to the granites, and the extreme alteration which they have suffered in this region, seem to show that they may be regarded as forming a thin overlapping edge on a general granitic substratum.

Smaller islands.

The north-east shore of Harbledown Island, with the south-west of Turnour Island (forming the opposite side of Beware Passage), together with Village Island, Indian Islands and the Cary Group, are composed of grey hornblendic granites, charged with numerous dark fragments, and intersected by dykes of intrusive rocks of several kinds. With the exception of a narrow tongue of flaggy argillites, which penetrates its southern side, Lewis Island is formed of the same granitic rocks.

Archipelago of Queen Charlotte Sound.

The west end of Gilford Island, also Midsummer, Bonwick, Mars, Hudson, Crib, Tracy, Eden, Insect and Baker islands, and the Benjamin Group, with innumerable small islets and rocks constituting the archipelago, are, with few and small exceptional points, composed of

rocks of the granitic series. The eastern parts of Turnour and Gilford islands were not examined. The exceptions above referred to, are found in a few small islands and rocks to the west of Midsummer and Bonwick islands, forming part of the outer edge of the archipelago, and are as follows:—

The south-west side of the outer small islet of the Sedge Islands, is composed of much altered quartzites and limestones, in thin, alternating beds. These are in contact with the granite, and traversed by granitic veins. Though much twisted, their average strike is about N. 50° W.

Remnants of Vancouver series, east end of sound.

House Island, half a mile due south of the last, is formed of quartzites, hard, flaggy argillites, and thin beds of limestone, the whole having a ribboned aspect, and the beds averaging from one to six inches thick. These beds also are much disturbed, but have a general south-westerly strike, and are vertical.

Canoe Islands, a short distance east-south-east of the last, are composed entirely of dark-coloured diorite or syenite, with much hornblende, and netted with granitic veins.

A little islet, without a name, at the north-west extremity of Midsummer Island, again shows a small mass of stratified rocks, like those first described, with a south-westerly strike. The neighbouring granitic rocks are charged with innumerable fragments of those of the stratified series.

In addition to the above localities, a small, much altered mass of the stratified rocks, was seen on Bush Island, north of Lewis Island, and the adjacent granites are full of regularly disposed dark fragments, like those of Tucker Point (p. 48 B). Another small mass of the same rocks was seen on an islet off the north extreme of Bonwick Island, and it is probable that still others may yet be found in this archipelago, as it would appear that the general line of separation between the granites and the overlying stratified rocks, slopes westward at a very low angle, in consequence of which small folds or faults have resulted in letting in little areas of the overlying rocks, here and there, even in the region generally characterized by granitic materials.

Character of junction with granites.

On the channel north of Insect Island, the granitic rocks were observed to be more or less gneissic in appearance, and the north-west point of Lewis Island is composed of a pinkish granite, differing from the usual grey variety, and with two felspars. Dark, highly hornblendic rocks, of granitoid texture, also appear in several places, and some of these might appropriately be classed as diorite, from their external appearance. On one of the small islets, west of the end of Midsummer Island, a dark rock of this character assumes a beautiful spheroidal concretionary structure, which is well shown on glaciated

Spheroidal diorite.

surfaces. The spheroidal masses are closely crowded together, their diameters being from two to four inches.

Superficial deposits and terraces are almost entirely absent from the whole of the islands of the archipelago which closes Queen Charlotte Sound to the east, the smaller islands being, as a rule, little else than solid masses of rock.

Foster and Numas Islands.

Foster Island, in the centre of the eastern part of Queen Charlotte Sound, is composed of stratified rocks, which from their appearance and relative situation, may be regarded as the continuation of those of Sedge and House Islands, previously described. Some of the rocks are quite schistose in aspect, with much hornblende and mica, but these are interbedded with quartzites and limestones in thin layers. The strike is about S. 52° E., and the beds are nearly vertical. Numas Island, ten miles further westward, and also in the centre of the sound, appears to be entirely composed of a dark, highly crystalline, dioritic rock, in which no bedding could be distinguished. It may be regarded as probably an intrusive mass.

North Shore of Queen Charlotte Sound.

Broughton Island.

Of Broughton Island—sixteen miles in length—the whole coast was examined, with the exception only of the upper part of Greenway Sound, which penetrates it on the north, and the heads of some of the deeper bays. The island is in general densely wooded, and several of the hills on its northern part surpass 1000 feet in height, though all are much inferior in altitude to many of those on the adjacent mainland, and occasional glimpses are caught of high, rugged mountains of the central parts of the Coast Range, still further to the north. Booker Lagoon, which opens from Cullen Harbour, on the south shore of the island, has bold, rocky shores, and, in addition to the usual grey hornblendic granites, considerable areas of dark crystalline rocks of dioritic aspect were here found. These are frequently cut by dykes and veins of the pale granite, and a gneissic lamination was seen in them in some places, though it is very doubtful whether this represents true stratification.

Cullen Harbour.

Shore west of Cullen Harbour.

The south side of the island, west of Cullen Harbour, shows a similar association of dark, highly crystalline, hornblendic rocks with the grey granites, and it is not improbable that these dark rocks here represent a final stage in the alteration of massive volcanic materials in contact with the granites. Fragments of the dark rocks are scattered through the granites in a number of places. On the east end of the inner of the Polkinghorne Islands (off the west point of Broughton Island) a dark dioritic rock of greenish appearance is interlami-

nated with grey granite, the lamination being vertical, with a strike of N. 45° W. Other parts of these small islands consist, so far as examined, of dark rocks of dioritic aspect, cut by pale granite veins or dykes. The northern half of Vincent Island, midway between the Polkinghorne Islands and Broughton Island, is composed of much altered flaggy argillites and quartzites, which, near their junction with the granites, become micaceous and hornblendic, and assume a gneissic appearance. Strike N. 57° W, with northerly dips at angles of 70° to vertical. The same rocks were afterwards again found, in the line of the strike just given, on the opposite side of Wells Passage, three miles to the westward. Flaggy argillites.

The west end of Broughton Island is composed of rocks so similar to those of the south shore that it is unnecessary separately to describe them, and the opposite side of Wells Passage, as seen across, appears also to be entirely of granitic rocks. The Kun-sta-mish Indian village, a favourite summer resort of the Indians, is situated just east of the entrance of Claydon Bay of the chart. Salmon are caught in considerable numbers at the mouth of a rapid river of some size which enters the west end of the Embley Lagoon, two miles north. This stream is not shown on the chart, and the outline of the lagoon itself is very imperfectly given. All the adjacent shores, examined or seen from a distance, are granitic. Near the mouth of the river above mentioned, hard Pleistocene clays, containing fossils, are exposed on the beach. These are again referred to in the sequel. Kun-sta-mish.

Grey granitic rocks characterize almost the entire north shore of Broughton Island, and as far as could be seen across Sutlej Channel, also that of the adjacent mainland. The only exceptions observed were:—Near the east end of Sir Edmund Head, where a small patch of hornblendic and micaceous schists occurs. Dip S. 10° E. $< 45°$; and near the east end of the island, opposite a small islet named Birmingham Island, where similar rocks were again noted. The west end of Pearse Peninsula, for a length of about a mile along the shore, is composed of similar hornblendic and micaceous stratified rocks, with an average strike of about N. 35° E. These probably run along the south shore of Deep Harbour, and possibly connect eastward with the last mentioned. The granites in the vicinity are full of dark fragments, which have sometimes been squeezed into lenticular forms, producing a laminated appearance. The strike of this superinduced structure was at one place, west of Pearce Peninsula, observed to be N. 38° E. With the exception of the above defined portion of Pearce Peninsula, the entire south shore of Broughton Island to the east of Cullen Harbour is granitic. North shore of Broughton Island. Shore east of Cullen Harbour.

Having at several times heard rumours to the effect that Indians Reported coal.

had found coal in the vicinity of Drury Inlet, I made enquiries on the subject while at Kun-sta-mish, but succeeded in learning merely that, many years ago, an Indian had gone about two days' journey up a small river which runs into Rocky Bay (Wells Passage), and had there found some material which was subsequently, from his description, conjectured to be coal. No trace of the Cretaceous sandstones was found in the whole region examined in this vicinity, and it is probable that the above mentioned report is entirely baseless.

Coast from Wells Passage to Blunden Harbour.

From Wells Passage to Blunden Harbour (eleven miles) the coast was examined by Mr. Dowling, who found it to consist chiefly of rocks of the granitic series, but to show in some places evident gneissic lamination of the kind previously described, and at many points to be filled with dark fragments. At one place, four miles west of Wells Passage, dark hornblende-schists appear, with a north-westward strike, and nearly vertical.

Blunden Harbour.

The shores of Blunden Harbour and Bradley Lagoon, opening off it, are likewise composed of granitic rocks, with some areas of the darker and more hornblendic variety already several times alluded to. A large part of the granite is closely packed with dark, fine-grained fragments, which have frequently been squeezed into lenticular forms, and even pass into sheets, which preserve their continuity for several yards. A laminated structure thus produced is often seen, the lamination running about N. 50° E., with a dip at a very high angle northward.

Our examination of the north shore of Queen Charlotte Sound terminated to the west at Blunden Harbour, the weather having become extremely unfavourable for further work on this open coast.

Malcolm, Haddington, Cormorant and Pearse Islands, and the adjacent Shore of Vancouver Island from Beaver Cove to Port McNeill.

Pearse Islands and the portion of the shore of Vancouver Island above defined, are composed, probably throughout, of rocks of the Vancouver series, with granites, while the remaining islands included under this heading are either formed of drift deposits or of Cretaceous rocks. The Pearse Islands are entirely formed of altered volcanic rocks, with light southward dips wherever their attitude could be ascertained. The rocks are generally greenish or grey and frequently epidotic, but in some places have a purplish-grey colour. While in a few localities, evidently altered amygdaloids and agglomerates, they are mostly compact. The whole group is very heavily glaciated, and shows no vestige of superficial deposits.

Pearse Islands.

Beaver Cove.

For a distance of a mile on its east shore, and on the west shore for

about half a mile, Beaver Cove is occupied by grey and reddish granite, while the remainder of its coast-line is formed of compact, greenish-grey felspathic rocks, which were at one place observed to have a probable strike of about S. 30° W. At a point about half a mile up the valley of the stream which empties into the cove, an attempt has been made to open a marble quarry. A number of good blocks have been got out, and some have been taken to Victoria. The marble is grey, often very prettily marked, and the situation is favourable for shipment. The felspathic rocks and associated marble much resemble those seen inland on Nimpkish Lake (subsequently described), and may probably be regarded as a continuation of the same beds. Rocks are exposed along the shore westward from Beaver Cove to a point opposite the east end of Cormorant Island. They consist of greenish hornblendic and greyish felspathic materials of volcanic origin. About the mouth of Nimpkish River, and thence westward to Port McNeill, no rocks are seen along the shore, which is presumably, though not certainly, underlain by the Vancouver series.

Marble quarry.

Cormorant Island.

Cormorant Island differs remarkably from the adjacent Pearse Islands, in being entirely composed of drift deposits, consisting for the most part of hard stratified silts. No rock in place is seen anywhere along the shores, and the island is flat-topped, with an average height probably slightly in excess of one hundred feet. The soil is rather sandy in character, and the surface densely wooded. At Alert Bay, on the south side of the island, is a large Indian village (I-lis), a salmon cannery, and a church and houses belonging to the mission.

Haddington Island.

Haddington Island is formed of grey Cretaceous sandstones, with a low northward or north-eastward dip, but considerably broken by a more noticeable vertical jointing. The sandstone is rather remarkable in character, being very fine-grained. It is well situated for quarrying, in blocks of moderate size, and would be very easily dressed.

Malcolm Island.

Conglomerate.

Malcolm Island resembles Haddington Island, but is much larger, being thirteen miles in extreme length. Its whole shore was closely examined; but rock in place occurs at a single point only, on the south side, due north of the centre of Cormorant Island. The rock is here a conglomerate, containing rounded pebbles of granite, and of the altered volcanic rocks, up to six inches in diameter, with occasional thin layers of sandstone. It is horizontal, or nearly so. This isolated exposure possibly represents a portion of the conglomerate subdivision (B.) of Quatsino. (See p. 87 B.) The remainder of the shores of Malcolm Island show only drift deposits, consisting of silts, sands and gravels, similar to those of Cormorant Island.

Like Cormorant Island, Malcolm Island is densely wooded, but with an even surface, and a general elevation, according to the chart, of 300

to 400 feet. The soil, wherever observed, is sandy and light, but nevertheless susceptible of cultivation, and the island will doubtless eventually be utilized for farming purposes.

Area of the Cretaceous rocks.

The occurrence of the conglomerate above noted, is of importance, as indicating the eastward continuation of the area of Cretaceous rocks which is seen along the shore of Vancouver Island from Port McNeill to Beaver Harbour, and as rendering it probable that rocks of this age may underlie a considerable part of the area of Malcolm Island. Boring operations, to determine the possible existence of coals which may underlie Malcolm Island, will doubtless eventually be carried out as the coast becomes more fully occupied by settlers. The southern edge of this portion of the Cretaceous is probably a faulted boundary. It must run nearly due east from Port McNeill, including Haddington Island, and possibly part of the north end of Cormorant Island, and then turning to the north or north-east, and pass to the west of Stubbs Island, which is composed of the older rocks.

Nimpkish River and Lake.

Nimpkish River.

Before describing the character of the coast of Vancouver Island, further west, a few notes may be given on Nimpkish River and Lake. The lake is named Karmutsen, on many maps, but is generally known as Nimpkish Lake. It is laid down on the map accompanying this report, from the results of a survey of its shores, made with a patent boat-log, its form, as thus ascertained, differing widely from that previously given. The Nimpkish (Kwā-ne) is a small, rapid, crooked stream, full of boulders, difficult of ascent at high water, on account of the strength of the current, and at low stages with scarcely sufficient water on the rapids to float a canoe. The distance, in a straight line, from the mouth of the river to the lake, is about four miles, and the total fall about one hundred feet. Some remains of an old Indian village are at its mouth, and a short distance below the lake, on the left bank, are a few houses, which are still inhabited by the Indians at certain seasons. The banks are densely wooded, and the land bordering the stream rather low. The salmon used in the cannery at Alert Bay, are caught in seines at the mouth of the river, while the Indians annually take a large number of these fish by means of traps and spearing.

Nimpkish Lake.

Nimpkish Lake is fifteen miles in length, with an average width of rather less than a mile. It occupies a portion of an important structural valley, which can be seen, continuing in a southward direction, for a considerable distance beyond its head. At the north or lower end of the lake, this valley bifurcates, one branch being now occupied

by the Nimpkish River, the other diverging in a north-westward direction. From this north-west valley, a stream about twenty feet wide enters the lake, and the valley is reported by the Indians to run through to the Klik-sī-we River, and to contain one or more small lakes. From the south-west angle, at the head of Nimpkish Lake, a wide, sluggish stream, about a mile in length, leads to a second small lake, about three-quarters of a mile long, called Anutz Lake on Trutch's map, but known to the Indians as Hē-lo-tzō. From this small lake, a trail leads across to a stream which flows into the head of one of the arms of Nootka Sound on the west coast, and was formerly used as a means of communication between the Indians of the east and west sides of the island. The only stream of any importance which flows into Nimpkish Lake, is the Nē-nil-gish, which enters about a mile from the head, on the east side. This river, which is from 150 to 200 feet in width at high stages, comes from the southern valley already mentioned, and according to Mr. H. Moffat, who explored it in 1852, drains a second large body of water, which is named Conuma Lake on later maps, but by Mr. Moffat, Lake Kanus.*

The west shore of Nimpkish Lake is everywhere bold and rough, rising, at a short distance, to steep hills and mountains of considerable height, the highest being Mount Karmutzen, with an approximate altitude of 5500 feet. The east shore, though often rough and rocky, seldom rises to a height of more than two or three hundred feet near the lake, and to the east end of the northern half of the lake, a relatively low country extends toward Beaver Cove. There are a few small rocky islets in the lake, the only ones of any importance being too near the middle of its length, which can be seen from almost all parts of the lake, and are known to the Indians as Sē-ko-youē, or Half-way Islands. Very little good timber was seen along the shores of the lake, but it is probable that better grown forests occur in the valleys opening from it, while cultivable land may also be found in the low country between the lake and Beaver Cove. Character of shores.

With the exception of a single area of granite, the rocks of the river and lake belong entirely to the Vancouver series. The granite occupies the west shore for a length of about two-thirds of a mile, opposite the Half-way Islands. Though generally grey, it is locally reddened and otherwise variegated in colour, and much fractured, and appears to come in contact with the altered volcanic rocks to the north along the line of a fault. The felspathic and diabase rocks of the river and lake offer no points worthy of special mention, being of the usual greenish Rocks of Nimpkish River and Lake.

* For Mr. Moffat's notes see Facts and Figures relating to Vancouver Island and British Columbia, by T. D. Pemberton, London, 1860, p. 143. Mr. Moffat calls Nimpkish Lake, T'sselth Lake, the Ne-nil-gish River, the Oakseey.

and bluish-grey colours, and often very compact and massive, though occasionally evidently altered amygdaloids. These rocks of igneous origin are, however, associated and interbedded with limestones and flaggy argillites and quartzites, the former here assuming unusual

Marble and flaggy argillites.

prominence, and being in most places converted into marble. The marbles occur in extensive exposures at points one and three-quarters, six and a half and nine miles, from the lower end of the lake, on its east side. From a point a mile and a half from the head of the lake, on the west shore, a grey crystalline limestone, still showing obscure traces of fossils, occupies the shore for over a mile. Opposite the limestones, on the east shore, are extensive exposures of hard, dark, flaggy argillites and quartzites, the latter paler in tint and often rusty. These beds here have an exposed thickness of from 300 to 400 feet. Fragments of somewhat similar argillaceous rocks, of a very dark colour, and showing obscure traces probably referable to *Monotis* or *Halobia*, are found in the gravel of the Klĕ-shum-e stream and its neighbour-

Reported coal.

hood, and have served to give rise to baseless reports of the existence of coal. Some undeterminable impressions of bivalve shells were also found in beds of grey, rusty quartzite or felsite, on the Nimpkish River, but nothing can be made of them from a palæontological point of view. On the river, the average strike of the beds is nearly east and west, with dips at high angles, both to the north and south. On the shores of the lake and in the vicinity, the beds generally lie at comparatively low angles, with dips which vary much in direction, and no connected section of the rocks was obtained. In limestone on the river, and in the grey limestone, previously mentioned, on the

Character of marble.

lake, cherty beds are common. The marble is generally fine-grained, and of various grey and mottled colours, and might be quarried with ease along low cliffs on the shore. These cliffs are frequently excavated into grottoes and small caves along the water's edge, and afford evidence of a rise of about ten feet above the summer level of the lake. The annexed cut gives a diagramatic representation of the mode of erosion of the low limestone and marble cliffs round the lake, and shows the peculiar uniform slope of the rock-surface below the waterline:—

FIG. 1. DIAGRAMATIC SECTION OF ERODED MARBLE CLIFFS ON NIMPKISH LAKE.

On the river, a few small, sandy and gravely terraces, identical in character with those of Cormorant Island, were noted.

Coast from Port McNeill to Beaver Harbour.

This coast, fourteen miles in length, is occupied by Cretaceous rocks, chiefly sandstones. It was examined by me when on my return from the Queen Charlotte Islands in 1878, but the results of this and other unconnected examinations made at the same time, were not included in my report of that year. In 1885 it was re-examined by Mr. Dowling and in part by myself.

Small Tertiary area.

Eel Reef, in Port McNeill, a small rocky patch, covered at high-water, is composed chiefly of brownish, blackish and reddish basalt, compact or vesicular in texture. The whole is much broken, and appears to represent a bed of agglomerate or breccia, made up almost altogether of basaltic material, but including also fragments of the green altered volcanic rocks and of Cretaceous sandstone. It is scarcely possible to determine whether any of the basalt forms part of a solid bed of that material, or whether it occurs merely as large fragments in the agglomerate. The mass is, however, undoubtedly post-Cretaceous, and probably synchronous with the Miocene volcanic rocks of the Queen Charlotte Islands, and is of interest as the only instance of undoubted Tertiary rocks met with in the whole area here reported on.

Cretaceous rocks of Port McNeill.

On the south shore of Port McNeill, and round the head of the harbour, no rock is seen, but the north shore and Ledge Point afford almost continuous exposures of Cretaceous sandstones, either massive or nodular, and often shaly. At a point on this shore from which Eel Reef bears S. 65° W. (mag.), a large collection of fossil plants was made. The rocks here dip N. 25° W. $< 10°$. The plants occur in beds of shales and shaly sandstones about five feet above a small seam of coal from one to two inches thick. These fossils include, according to Sir Wm. Dawson, a number of dicotyledonous leaves of different genera, together with a *Salisburia* and a *Taxodium*. Some of the species seem to be identical with those of the Productive measures of Comox and Nanaimo, but many are distinct. They are either referable to the same horizon with these or to a slightly older one.

Fossil plants.

Ledge Point is formed of a coarse, nodular sandstone which weathers brownish. From Ledge Point all along the shore to within half a mile of Thomas Point (the south entrance point of Beaver Harbour), low exposures, chiefly of sandstones, with occasional beds of shale, are frequent on the beach. At one place, three miles west of Ledge Point, the sandstone becomes conglomeritic, holding pebbles up to six inches

Former coal mining at Suquash.

in diameter. The angles of dip of these beds are invariably low, seldom exceeding ten degrees, and the direction somewhat inconstant. Thin seams of coal, which appears to be of good quality, are seen in several places along the shore. At Suquash or Sa-kwash, coal was at one time mined by the Hudson's Bay Company, on a limited scale, and I am informed that in all from 9000 to 11,000 tons was obtained. A short tunnel was driven and other exploratory work carried out, which is subsequently referred to. The seams as now visible on the beach at this place, are two in number, the upper being at least one foot, and in places probably two feet in thickness. It is separated by about a foot of soft shale from a lower seam with a maximum thickness of about six inches.

Other local outcrops of coal.

A quarter of a mile south-eastward from the old wharf, two seams, each about an inch in thickness, are seen on the shore. Westward, half a mile beyond False Head, is a seam of five inches thick; and three-quarters of a mile still further west, a coal outcrop of four inches in thickness occurs. Again, near the mouth of the Kī-uk River, two miles from Point Thomas, two seams of six and three inches respectively were found. Thomas Point is composed of the underlying volcanic rocks, but to the west of it, opposite Fort Rupert, on the shore of Beaver Harbour, small areas of sandstones and shales are found dipping off the older rocks. Some plants were collected in these shales in 1878, among which Sir William Dawson has found a *Neuropteris* and a *Salisburia*,* which appear to be of Middle Cretaceous age.

Klik-si-wi River and vicinity.

The Klik-sī-wi River reaches the coast at a point directly opposite the west end of Malcolm Island, and was found by Mr. Dowling, when on an excursion inland from the head of Port McNeill, to occupy a valley to the east of two conspicuous hills marked on the chart. No rock exposures were, however, found till the summit of the southern of the hills above mentioned was reached, and the rocks there seen (trachytes) are probably intrusive. The Klik-sī-wi River was afterwards ascended for about two and a quarter miles from its mouth, for the purpose of examining a reported coal seam, which, however, proved to be from two to three inches in thickness only, though overlain by about three feet of coaly shale. The beds were found to be practically horizontal. On another small stream which reaches the sea west of the Klik-sī-wi, at a point about three-quarters of a mile due south of the mouth of the Klik-sī-wi, a prospecting hole was made many years ago. The seam is here about sixteen inches thick, and dips eastward at an angle of about 5°, though the beds else-

Coal seams.

* See Trans. Royal Soc. Can., Vol. I., Sect. IV., p. 15.

where in the brook are nearly horizontal. From its appearance and that of the associated beds, the coal here exposed is probably the same with that last alluded to. It further appears quite probable that the coals at Suquash represent a further continuation of the same bed. A short traverse was made by Mr. Dowling up the bed of the stream at Suquash, but without developing any facts of importance or reaching the western edge of the coal-bearing rocks. Like nearly all the streams in the northern part of the island, this is extremely difficult to examine or follow, owing to the thick growth of forest and underbrush and tangled masses of fallen timber.

Rocks on trail toward Quatsino.

A traverse was subsequently made by Mr. Dowling, of a part of the trail from Fort Rupert toward the head of Quatsino Sound. A small stream was reached at about four and a half miles nearly due south from the fort, which flows into the Kl-uk River, and the latter was followed down to the coast. On this small stream and on the river, sandstones occur, and are either horizontal or show very light, irregular eastward dips. Thin streaks of coal were seen at one point on the river, and a new species of *Placenticeras* (described in the appendix) together with casts of a small *Mactra* or *Cymbophora*, were found.

General arrangement of Cretaceous rocks in this vicinity.

The low undulating character of the dips along the coast between Port McNeill and Beaver Harbour, and the existence of several rather considerable intervals in which the rocks are concealed, precludes the possibility of arriving at any accurate estimate of the thickness of the Cretaceous rocks there exposed, or of presenting a complete section of them. It appeared at first probable that the entire thickness was very inconsiderable, but the existence of fossils, which are probably referable to the lowest beds of the Quatsino region, (See p. 84 B, 91 B) in the rocks of one end of this shore-line, (at Fort Rupert), while those at the other extremity, (at Port McNeill), evidently belong to a much higher stage in the Cretaceous, appeared to call for some explanation. On carefully plotting the observed attitudes of the rocks, it became evident, that notwithstanding local irregularities, there is a general tendency to north-west by south-east strikes, while dips in a south-easterly direction also greatly preponderate. A section based on these dips, shows that a total thickness of about 6000 feet of beds may easily occur between Beaver Harbour and Port McNeill, the beds at the latter place being the highest. This would be amply sufficient to account for the difference of horizons indicated by the fossils.

Against this explanation it must, however, be urged, that the thickness of the lowest sub-division at Quatsino (A. see p. 84 B) is probably not greater than 3000 or 4000 feet. There is every reason to think that the section in this contiguous area is similar, and in this case the massive conglomerates of Quatsino (B. p. 86 B) should appear about

midway between the extreme points, or near Suquash, where the Cretaceous beds should be, according to the dips, about 4000 feet thick. No such massive conglomerates are, however, seen, and it is improbable that beds of this character are concealed beneath low parts of the shore. There is, however, at Suquash, a decided appearance of faulting, and on consideration of the facts, so far as known, I am inclined to believe that an extensive down-throw here occurs to the southward along an easterly and westerly line. On this hypothesis, the beds along the shore south of Suquash, are much newer than those to the north, being entirely above the conglomerates (B.) and nearly equivalent to the lowest beds of the Nanaimo and Comox basins, as their contained fossils would indicate. The close lithological resemblance of these beds to those seen near Oyster Bay (p. 17 B) lends countenance to this view, according to which the massive conglomerates seen at one place on Malcolm Island (p. 57 B) may represent a portion of subdivision B., of Quatsino, which here appears at the surface owing to a less throw in the fault to the eastward.

Probable fault at Suquash.

Fault bounding measures to south.

The line of the main fault which bounds the Koskeemo coal-basin to the south, if continued eastward, passes nearly through Port McNeill, and it appears probable that this fault does actually so continue, with a similar extensive downthrow to the north, bounding the Cretaceous rocks in this direction, and accounting for the non-appearance of the conglomerates (B.) and lower beds (A.) at the southern edge of the basin. The occurrence of the small Tertiary volcanic patch of Eel Reef may be in connection with this important fault.

Other conditions.

The facts in evidence are not sufficient to prove the hypothesis above stated, which may, nevertheless, be of use as a guide in the future exploration of the field. The rock met with at the bottom of boring No. 2, at Suquash, (p. 67 B) might be assumed to belong to the Vancouver series, at the base of the Cretaceous, which must, in this case, be quite thin. It is quite as likely, however, that the rock here reached was in reality the top of the massive conglomerate subdivision.

Composition of coals.

As further confirming the view that the beds at Suquash and southwards represent a horizon lower than those to the north, the analyses of coals from the southern and northern parts of this shore-line given on a subsequent page, may be referred to. A fuel from the Kī-uk is a true coal with strong coke, resembling the Coal Harbour specimen, while fuels from Suquash and Klik-sī-wi closely approach lignite-coals in character.

From the above notes, it will be apparent that the extension inland of the Cretaceous coal-bearing rocks, which occupy the shore from Port McNeill to Beaver Harbour, has not been determined. This

must be ascertained by the laborious process of tracing their boundary in the wooded interior. The continuously low character of the country between Klik-sī-wi and Rupert Arm of Quatsino Sound, appears, however, to indicate the probability of a wide area of Cretaceous rocks. Here, as elsewhere in the northern part of Vancouver Island, it appears that the present surface of the country nearly coincides with the old denuded surface of the Vancouver rocks upon which the Cretaceous was laid down. Whether the Cretaceous was originally deposited only in hollows and valleys among these older rocks, or formed a nearly continuous sheet, of which portions still remain only in these hollows, is as yet uncertain. In either case, however, the result is the same, leading to the appearance of the Cretaceous in isolated patches of irregular form, and sometimes in the most unexpected places—so much so, that till every square mile of the country has been systematically examined, it will be impossible to affirm that all existing outliers are known. Those outliers, however, which have the greatest area, and are on or near the shore, are naturally the most important, and these, fortunately, are not so difficult of discovery and definition. It is probable that about four weeks of work inland will be necessary to fix, with approximate certainty, the outlines of the Cretaceous region here specially described. General features of Cretaceous outliers.

Respecting the probability of the discovery of really important coal seams in this area, little can as yet be said with certainty. Those so far found, are all quite thin. The regularity of the beds, the low angles at which they lie, and the long stretch of coast characterised by them, are all in favour of mining operations, should thicker seams be developed. When it shall become important to determine the coal-bearing character of the rocks, boring operations of a systematic character will have to be resorted to. Coal deposits.

Through the kindness of Mr. G. Blenkinsop, formerly of the Hudson Bay Company, I have been put in possession of some records of borings already made by that company, in 1852, near Suquash, and at the mouth of the Kī-uk River. These records are signed by Boyd Gilmour, a miner employed by the company to search for coal. They appear to have been kept with some care, but the nomenclature applied to the various rocks is such, as in some instances to leave it in doubt what the beds penetrated actually were. In such cases, the names used in the original logs are retained. Borings for coal by Hudson's Bay Company.

No. 1. Boring at Kī-uk River, on the beach, about two and a half miles from Fort Rupert. Boring at Ki-uk River.

5

	FEET.	INCHES.
Gravel and shingle	7	6
Hard confused sandstone	16	7
Dark grey freestone	12	6
Dark scaly tile coal	1	6
Grey freestone	11	0
Freestone, flakes dark coloured	5	6
Grey, hard sandstone	29	4
Dark coloured clayey stuff	1	3
Grey flagstone, "with dougars and kingle plays"	23	4
Dark coloured stuff with coaly streaks	1	3
Dark freestone	10	6
Dark sandstone	60	2
Whin	..	2
Total	180	7

Boring at Suquash.

Boring No. 2 was made at Suquash, on the beach, below a "cliff or scar." It is stated that the section in the cliff should be added to that obtained in the hole. The cliff section is as follows, according to Gilmour's notes :—

	FEET.	INCHES.
Brownish freestone	10	0
Grey shaly stuff	13	5
Good coal	0	5
Brownish freestone	18	0
Good coal	0	4
Freestone, in which the boring commences	10	0

Boring No. 2, is then given as follows :—

	FEET.	INCHES.
Freestone	6	0
Grey, soft sandstone	21	5½
Hard freestone	1	4
Soft freestone	0	10
Coal parting	..	..
Coarse fire-clay	0	5
Grey shaly or clayey stuff	7	3
Hard freestone	3	4
Hard freestone, confused	1	3
Soft clayey stuff, with white balls	6	3½
Soft, grey flakey stuff	2	11
White, soft stone, with soapy feel	2	11
A coaly stone	1	11
Grey flaky material	5	10½

	FEET.	INCHES.
Flaky freestone	6	0
Dark grey freestone	12	0
Very hard confused rock	0	8½
Very hard stone	1	8
Dark grey freestone	0	10
Hard, bluish-green stuff	2	6½
Very hard stone	0	7½
Very hard confused rock	1	10½
Grey freestone	2	9
Dark clayey sandstone, without partings	6	1½
Grey freestone	3	2½
Very hard confused rock	2	3
Grey freestone	2	9
Dark grey clayey sandstone	2	4
Dark grey stuff	5	8
Hard grey freestone	3	10
Hard grey freestone	12	4
Hard white stuff	6	5½
Dark clayey stuff	0	1½
Whitish hard stone	3	8
Hard freestone	3	1
Hard, dark freestone	3	9
Dark clayey stuff	4	2
Dark grey clayey stuff, without partings	3	9
Dark and a little more clayey	1	7
Hard freestone	0	4
Light grey clayey stuff	1	0
"Dougar plays"	2	6
Greenish-blue clayey stuff	2	5½
Dark clayey stuff	1	5
Very dark stuff	2	1
White, soft freestone	5	9
Very hard freestone	3	0½
Soft freestone	8	6
Grey clayey stuff	6	10
Grey clayey stuff, without partings	3	5
Sandstone full of boulders (nodules?)	4	6½
Similar, but darker coloured	1	9
Dark coloured stuff, some coaly streaks	4	11
Dark rock, "Dougar plays"	10	0
A dead grey coloured sandstone. The only change in this stuff is from a lighter to a darker colour	60	9
Very hard, green whinstone, much mixed with white spar	2	0
Total	329	4½

Boring No. 3. This boring was, according to Mr. Blenkinsop, about two miles inland from Suquash, and, on the hypothesis previously

Boring near Suquash.

stated, must be to the north of the Suquash fault and in beds equivalent to subdivision A., at Quatsino.

	FEET.	INCHES.
Whitish clay, sand and shingle, alternating	31	6
Grey flakes	25	6
Soapstone	1	0
Dark grey stuff	3	0
Light-coloured soft freestone	3	0
Confused soft sandstone	0	10
Hard, greenish stone	3	6
Dark, sandy stuff, with coaly streaks	2	6
Light-coloured freestone	5	5
Confused sandstone	5	5
Confused sandstone, not so hard, and darker	8	0
Dark freestone	19	8
Dark slaty stuff	21	6
Dark clayey stuff	1	10
Clean coal	0	4
Coarse fire-clay	2	8
Greyish freestone	9	10
Light-coloured freestone	15	0
Greenish sandstone	16	9
Dark-coloured stuff, with coaly streaks	1	3
Clayey stuff	5	11
Spotted or mixed freestone	2	8
Dark clayey stuff	2	5
Dark scaly stuff, with coaly streaks	5	6
Dark grey sandstone	18	1½
Dark clayey stuff	2	5
Dark greyish sandstone	27	8½
Dark clayey stuff	3	6
Dark grey sandstone	2	3½
Dark clayey stuff, slight coaly streaks	5	4½
Light-coloured sandstone	1	0
Grey shaly clay	16	3
Dark grey sandstone	10	10
Dark grey dead stuff	1	11
Hard, grey sandstone	0	11
Total	285	4

Remarks on borings.

Of Boring No. 1., it is remarked that an open "cutter" was struck in the whin, which yielded a great quantity of salt water, though the hole was begun a six or eight feet above high-water mark. This hole was abandoned owing to the loss of the boring rods. As no description of the "whin" in which it terminated is given, it remains uncertain whether the Cretaceous rocks were completely passed through, though from the proximity of the older rocks to the Ki-uk River, it is not improbable that this was here the case.

Boring No. 2., at Suquash, has already been referred to on page 64 B. It may have ended in the massive conglomerates, of subdivision B., of Quatsino.

The result of these borings must certainly be considered as unfavourable to the view that the Cretaceous, in this part of its extent, includes coal-seams of importance. There is, however, it may be added, a persistent rumour that a coal-seam, six feet in thickness, was reached at Suquash, but not reported, owing to the wish of the men engaged to discontinue operations at this place. Under the circumstances, little weight can be given to such a report. If further work should be contemplated in this region, I should be inclined to advise an experimental boring on the south shore of Malcolm Island, at the locality of the occurrence of the conglomerate. This would test an entirely new portion of the field.*

The following assays of coals from three points on the coast between Port McNeill and Beaver Harbour have been made by Mr. G. C. Hoffmann in the laboratory of the Survey.

From small seam of coal on stream about three-quarters of a mile south of mouth of Klik-sī-wi River. This coal produces a coherent but tender coke, and is considerably acted on by a solution of caustic potash. Assays of coals.

Hygroscopic water	3·65
Volatile combustible matter	42·23
Fixed carbon	39·84
Ash	14·28
	100·00

From Suquash. This coal yields a moderately firm coke, and is considerably affected by a solution of caustic potash, yielding a brownish-yellow colour, like the last.

* Dr. W. F. Tolmie, in 1835, was the first to make known the occurrence of coal on this part of the coast, this being also the first discovery of coal on Vancouver Island. See Bancroft, History of British Columbia (1887), p. 186, and Tolmie's statement, given as a foot note in the same volume (p. 189). Bancroft closely follows Grant in his account of the early exploration of the coal, but falls into error with respect to Port McNeill and Beaver Harbour, which he regards as alternative names for a single place. This is clearly shown by the latitudes quoted by him on p. 189, which are correct and not erroneous, as he assumes. The original coal mine was at Suquash, to which Port McNeill was the nearest convenient and safe anchorage. Fort Rupert was afterwards (1849) founded at Beaver Harbour, which then became the chief point of call. Ellenborough Promontory (p. 191) is evidently Ledge Point, and Bailie Hamilton's Bay is near the position of Suquash. There is also some confusion as to the dates between which systematic exploration of the coal was carried on by miners imported by the Hudson's Bay Company. The work occurred between 1849 and 1851, according to Bancroft; but that it was continued till 1853, is shown by the fact that the original record of boring No. 2 at Suquash (communicated to me by Mr. G. Blenkinsop) states the progress of each day's work, beginning on Monday, October 30, 1852, and ending July 8 (1853?). Though it is impossible now to locate the places described by Grant as those at which work was done, it is evident from the details which he gives, that several trial shafts and borings, besides those of which I have been able to obtain records, were made.—See Description of Vancouver Island, by W. C. Grant, Journ. Royal Geog. Soc., Vol. XXVII. (1857), p. 275.

Hygroscopic water	5·03
Volatile combustible matter	41·51
Fixed carbon	46·52
Ash	6·94
	100·00

From a thin seam at Kī-uk River. This coal yields a firm coherent coke, and is scarcely affected by a solution of caustic potash.

Hygroscopic water	3·68
Volatile combustible matter	39·29
Fixed carbon	47·03
Ash	10·00
	100·00

Beaver Harbour to Shushartie Bay.

Rocks of Hardy Bay.

With the exception of the Cretaceous outlier on the beach opposite Fort Rupert, the rocks seen along the shores of Beaver Harbour, and on the islands off it, belong exclusively to the Vancouver series, being generally dark greenish, altered volcanic materials, and occasionally evident altered amygdaloids. The general dip appears to be south-eastward, at angles of 40° to 45°.

Rocks of Beaver Harbour.

Hardy Bay, which is separated by a narrow hilly promontory from Beaver Harbor, is also chiefly bordered by the volcanic rocks of the Vancouver series. These rocks show dips to the south or south-east in a few places, at somewhat lower angles than the last, from which they also differ in the notable prevalence of reddish and purplish beds.

Cretaceous outlier.

At the bottom of Hardy Bay, on the west side, the shore is occupied, for about a mile and a half, by Cretaceous rocks, forming an outlier on the older series. These rocks are chiefly soft, greyish sandstones, which sometimes become pebbly, and pass into true conglomerates. They form flat exposures along the beach, chiefly between high- and low-water marks, the total thickness seen being very small. A small stream, known to the Indians as the Wa-kī-law, was followed up for a distance of over a mile, for the purpose of ascertaining the inland extension of this outlier. The beds are at first flat, or dip seaward at nearly the slope of the bed of the stream. Again, further on, they undulate at various low angles, and were eventually found dipping seaward off the surface of the older rocks. The appearance is, however, that of an unconformity by overlap, the bottom beds of the Cretaceous being probably not seen, even at the line of junction with the crystalline series. The same thing doubtless occurs at Fort Rupert, the Cretaceous sandstones having filled hollows on an irregular surface,

Wa-ki-law River.

and having been since largely removed by denudation. The older altered volcanic rocks, where seen below the Cretaceous, are somewhat decomposed and soft, easily broken with the hammer, and shaling off along jointage planes, etc. They are very different in appearance from those exposed along the present shore, which are usually hard, and often quite smoothed by glacial action.

Several years ago, Mr. John McAlister carried out some small prospecting operations, for coal, on this Cretaceous outlier. Some holes were sunk on the beach, but to an inconsiderable depth, and without finding any coal.

The Wa-kĭ-law River, according to Indian report, rises in a lake nearly a mile in length, at a distance of about three miles from the shore.

The Kowat-se (or "West-side") River, which enters Hardy Bay, at the head, in the south-west angle of the shore, is a larger stream than the last, having a flood-water channel of 100 to 150 feet in width. It is reported, also, to rise in a lake, which is said to be of considerable size. For about a mile and a half from its mouth, which was the extent of my examination of it, it is blocked with heavy masses of fallen and drift timber, and the land bordering it is all low. The Cretaceous rocks forming the edge of the outlier last described, probably underlie the mouth of this river, but are concealed, and must be quite narrow, as a short way up stream, the rocks of the older series are seen. Three-quarters of a mile from the shore, a small detached outlier of coarse Cretaceous conglomerates appears, with a width of about quarter of a mile. The altered volcanic rocks are seen both above and below this patch, the existence of which shows how probable it is that numerous outliers, as yet unknown, may occur at a distance from the shore in this part of Vancouver Island. Kowat-se River.

At the head of Hardy Bay is a salt marsh, with an area of about eighty acres, covered with good grass. In the vicinity of this bay, and southward from Beaver Harbour, there are considerable tracts of low, level land, all now heavily timbered, but which may eventually be reclaimed for agriculture. Grass land.

From Duval Point, at the west side of Hardy Bay, to Shushartie Bay, a distance of fifteen miles, the coast of Vancouver Island was examined by Mr. Dowling. This shore, which forms the south side of Goletas Channel, is almost perfectly straight, and is throughout very bold and rocky, with small sandy beaches at a few places. It is bordered by a series of hills and low mountains, which exhibit remarkably uniform conical forms. The channel evidently follows an important structural break of some kind, which is parallel in direction to the northern part of Quatsino Sound, and nearly coincides with the general South shore of Goletas Channel.

strike of the beds, so far as this could be ascertained. The rocks belong entirely to the Vancouver series, and present no features worthy of special note. They consist, for the most part, of dark green, altered amygdaloids and agglomerates, which look nearly black at a distance.

Hope and Galiano Islands, and the Gordon Group.

Hope Island. With the exception of the shores of Bull Harbour, which were examined by me while detained there by gales in the autumn of 1878, the following notes on Hope Island, are due to Mr. Dowling. The north-eastern shore is bordered by dark-coloured rocks which appear to be much altered felsites, and probably form a continuation of the altered volcanic materials of the north part of Galiano Island. The greater part of the eastern portion of Hope Island, together with the western extremity of the western portion, is composed of rocks of the granitic series, which seem, however, often to be darker in colour than usual.

Bull Harbour. With the exception of granitic dykes, the shores of Bull Harbour and the south coast on both sides of it, for some distance, are composed of rocks of the Vancouver series, amongst which flaggy argillites are largely represented, of which the felspathic beds at times become almost gneissic on approaching the granites. The general strike of these rocks is about north-west. In my notes of 1878, the rocks of Bull Harbour itself, are said to consist of hard felspathic materials, probably altered ash-beds or felsites, pale in colour, but weathering to a bronzed surface. These are generally pretty well bedded, though sometimes brecciated, and pass into hard, blackish, much fractured argillites, in which no fossils could be found. In a few places, the rocks are nearly horizontal, but they are generally much disturbed, turning up suddenly at all angles, and also violently flexed and crumpled. There are many small faults, some of which are parallel to the direction of the harbour, which is probably due to the weathering out of the rocks described along one or more of these lines of fracture. Bull Harbour, has evidently at one time been a passage, separating Hope Island into two parts. It is now closed at the north end merely by gravel deposits, which have been banked up by the action of the outer surf.

Outlier of sandstone. In the wide bay at the east end of Hope Island, directly opposite Vansittart Island, there is on the beach, overlying the granitic rocks, a small outlying patch of grey and yellowish soft sandstones, nearly horizontally bedded, and probably referable to the Cretaceous, though no fossils more characteristic than broken shells of *Ostrea* were found in them.

North-west shore of Galiano Island. The greater part of the north-west shore of Galiano Island is composed of granitic rocks, which generally show two varieties of felspar,

one being of a pinkish colour. They are charged with numerous dark fragments, which, in some places, form about half of the entire mass. Opposite the north-east end of Vansittart Island, there is a small connected area of fine-grained, blackish, hornblendic rock, in character precisely resembling that of the fragments above alluded to. No bedding could be made out, but I feel little doubt that this represents a much altered included portion of the Vancouver series. At the same place, is a small stream, which, according to Indian report, drains a long lake, occupying a valley which runs toward the head of Port Alexander. Vansittart Island is low, and formed of dark rocks, evidently, of the stratified series, but was not visited.

The island in the centre of the bay at the north end of Galiano Island, is composed of granite, but the bottom and east shore of the bay, together with the north extremity of Galiano Island, is composed of dark, flaggy argillites and quartzites of the character already frequently described, but here interbedded with thin grey-blue limestones. The whole forms a series of compressed folds, with a strike of about S. 35° E. On the north-east shore of the island are similar flaggy argillites, interbedded with volcanic materials, some of which are evidently altered amygdaloids, and generally dip north-eastward at high angles. At the extremity of the point which forms the east side of Port Alexander, similar argillites are found interbedded with hard grey sandstones, which pass into quartzites. The shores of Port Alexander are chiefly of argillites, which, in some places, become quite thin and slaty, and yielded a couple of obscure fossils, one of which is, however, probably referable to *Belonites Vancouverensis*. The rocks are either vertical, or have a very high north-eastward dip, with a persistent strike of N. 35° W. They evidently run through on this strike from the north end of Galiano Island.

North-east shore.

Port Alexander.

For over a mile west of Port Alexander, on the south shore of the island, are greenish and grey altered volcanic materials, which must underlie the argillites. Further west, the granitic rocks form the greater part of the shore, though two much altered and disturbed patches of flaggy argillites and quarzites also occur. These, at one place, a mile and a half from the west end of the island, include a rather thick bed of bluish impure limestone, which is interbedded with quartzite, and dips inland from the shore, or northward, at an angle of about 30°.

South shore.

Balaklava Island, which adjoins Galiano Island on the east, appears to be almost entirely composed of the flaggy argillites and associated rocks, with probably some altered volcanic materials. The strike is in general parallel to the longer axis of the island, but this, together with the angle of dip, is somewhat variable. Large exposures of greyish limestone, dipping S. 87° E. < 60°, appear on its west side, near the north point. The south point is composed of sandstone, like that of the east

Balaklava Island.

point of Port Alexander. The limestone above mentioned, probably conformably overlies the argillites of the west part of Galiano Island.

Hurst Island. The whole southern part of Hurst Island is composed of grey granite, which is usually of the ordinary hornblendic character, but in some places contains a considerable proportion of black mica. Its northern side is formed of flaggy argillites, which are often altered to true lydian-stone. These are interbedded with calcareous layers, and occasionally hold calcareous concretions. Felsites of grey tints also occur, and are apparently interbedded. The dip of these beds is from S. 28° E. to S. 43° E. at an angle of about 40°, and they appear to form the north-east side of a synclinal, repeating the beds of the north-east shore of Galiano Island.

Bell and Heard Islands. Bell and Heard Islands are in the line of strike of the rocks last described, and are similar in character, with dips in the same southwestward direction. Duncan Island was not visited, but appeared also to be formed of similar dark-coloured rocks.

Miles Cone. The small islands between Heard Island and Miles Cone, are masses of altered volcanic rocks, which in some places are evidently agglomeritic or amygdaloidal. On the west side of Miles Cone, which forms a remarkable land-mark, rising steeply to a height of 380 feet, bluish-grey, fine-grained felsitic rocks are interbedded with flaggy argillites, with a dip of S. 25° W. $<$ 45°. No granite was seen in these small eastern Islands of the Gordon Group.

Walker Islands. The Walker Islands, lying in the middle of Queen Charlotte Sound, were not visited. From a small island, near the north-west end of this group, a very rich specimen of magnetic iron ore was given to the late Mr. James Richardson. Owing to their exposed position, these islands can be visited only in fine weather, and the time at my disposal did not suffice to enable me to examine them.

General note on islands north of Goletas Channel. The islands to the north of Goletas Channel, of which the geological features have just been noted, are in general densely wooded, wherever the surface is not composed of bare rock. Owing, however, to their exposed situation, the trees are of inferior size and quality. The most prominent hill is Mount Lemon, on Galiano Island, with a height, according to the chart, of 1200 feet. Drift deposits occur here and there in sheltered places, forming small, low terraces. The only permanently inhabited Indian village is that known to the whites as the Nawitti village (Mĕl-oo-pa of the Indians), and is on the south-east shore of Hope Island. At this place there is a good anchorage for small vessels, in Nawitti Cove, which is outlined on the charts but not surveyed. The strong tidal currents running past its mouth render it, however, rather difficult of entrance.

In reviewing the general geological features of these islands, we cannot but be struck with the fact that the granitic rocks of this vicinity are confined to them, and do not occur on the opposite shore of Vancouver Island. In the occurence near the line of junction of these rocks and those of the Vancouver series, of the flaggy argillites and associated limestones, and in the existence, along the same line, of a straight and deep channel (here Goletas Channel), the conditions observed further south, about Johnstone Strait, are repeated.

Shushartie Bay to Cape Scott.

Shushartie Bay to North-west Nipple.

From Shushartie Bay, the coast-line runs westward twenty-two and a half miles, to Cape Scott, the north-western point of Vancouver Island. It is in general low, with rocky points, which separate wide, sandy beaches. No hills of great height exist in the northern extremity of the island, and the bottom shoals gradually for several miles off shore. Many parts of this shore are laid down very imperfectly on the charts. From Shushastie Bay, to a bay three miles beyond Cape Commerell, the rocks of the coast are entirely altered volcanic materials, which repeat the characters of those observed to the east of Shushartie Bay. They are generally greenish in colour, and often evident altered amygdaloids, with southward dips at angles of 30° to 50°, wherever the attitnde could be ascertained. Near North-west Nipple, and elsewhere, whitish, felspathic dykes, which weather red from contained pyrite grains, are seen cutting the rocks.

The rock at North-west Nipple is dark greenish-grey in colour, and very compact, and probably represents an altered lava. In composition it was found, on microscopical examination, to be a decomposed diabase.

Coast west of North-west Nipple.

Between North-west Nipple and the bay just referred to (for which no name appears on the chart), the strike of the beds gradually changes to a north-westward direction, the dip being to the south-west. On the east and west sides of the bay, inside the entrance points, granite appears, and it probably continues round the bottom of the bay also, though no exposures are here seen on the beach. The granite here differs somewhat from that usually found, and resembles in appearance and mode of occurrence that describled on Nimpkish Lake. It may in both cases be regarded as probably of intrusive origin, and lies to the west of the general line of junction of the granitic and Vancouver series, the phenomena connected with which are elsewhere discussed.

Two streams, known to the Indians as the Ya-kwan and Kao-sa-a, respectively enter this bay. The first mentioned is the more important and is esteemed a good salmon river. The Indians occasionally travel across from here to the West Arm of Quatsino Sound, and as the

distance of thirteen miles in a direct line is said to be made in one day, the trail must be an exceptionally good one for Vancouver Island.

Synclinal.

West of the granitic intrusion above described, the green, altered volcanic rocks resume, and about a mile further on, in the second of two small, shallow bays, there is a regular ascending section, with south-westward dips, at angles of 20° to 40°, showing a great thickness of limestone, argillites, sandstones, etc., overlying the volcanic rocks. From smaller exposures seen in the next long sandy bay, it is probable that this forms one half of a synclinal, the greenish, volcanic rocks again coming to the surface near the position of Nahwitti Cone of the chart. I was unable to give this part of the coast as detailed an examination as its geological interest seems to merit, in consequence of the heavy sea, which was at the time rolling in upon it, but the main features appear to be as follows.

Probable sequence of rocks.

The greenish and greenish-grey, hard, felspathic, volcanic rocks are followed, apparently in regular ascending order, by massive greyish-blue, cryptocrystalline limestone, which occasionally becomes almost a marble, and is often cherty. This is cut by pale-grey, red-weathering, felsite dykes, and must be several hundred if not a thousand feet in thickness. Above this is a considerable thickness of hard, bluish, flaggy limestones, interbedded with calcareous argillites, black, flinty argillites and felsites, and holding in some layers a few fossils, amongst which *Halobia Lommeli*, and *Arcestes Gabbi*, have been recognised by Mr. Whiteaves. These rocks are followed by very hard, greenish, calcareous sandstones, with some softer, yellowish layers, the whole closely resembling the sandstones of the east side of Port Alexander, before noticed. Above these is a considerable thickness of rocks, apparently for the most part very hard, grey sandstones, passing into quartzites, and weathering red, from contained dolomitic matter.

Thickness of limestones and argillites.

The thickness of the entire mass of ordinary sedimentary rocks here overlying the altered volcanic materials must be in the vicinity of 2500 feet. The series, as a whole closely resembles that seen, but less perfectly, on Nimpkish Lake, and almost exactly reproduces the section measured in 1878, in Section Cove, Queen Charlotte Islands. The age of the upper portion at least of the limestones is definitely shown to be that of the Alpine Trias by its contained fossils.

Coast from Nahwitti Cone to Cape Scott.

From Nawitti Cone to Cape Scott the coast is chiefly composed of altered volcanic rocks, which are often distinctly amygdaloidal, and not infrequently show reddish tints. The dips are rather irregular, and no well-marked sequence could be made out. Four and three-quarter miles east of Cape Scott, a well-stratified band of grey limestone, about thirty feet thick, runs across a low point. It is interbedded with the volcanic rocks, being underlain by amygdaloids and agglomerates, and

overlain by an amygdaloid. An amygdaloid, holding thin layers of limestone is again seen on the west side of a bay, two and three-quarter miles east of the cape. Further east, in the same bay, (which, as shown on the chart, is very much too deep) isolated exposures occur on the beach near low-water mark, of hard, greenish-grey, calcareous sandstone, which in some layers contains fragments of *Inoceramus*, or some similar shell, with a pronounced prismatic structure. Similar exposures of sandstone again occur in the next shallow bay, a mile and a half east of the cape. The lowest thin bed of the sandstones at this place, is an arkose-like rock, largely made up of crystalline grains of red felspar. It is highly calcareous, and rests upon a very rough brecciated surface of the greenish volcanic rocks, into the fissures and crevices in which crystalline calcite has penetrated. The exposures are again on the beach, near low-water mark. The sandstones of this and the last mentioned place are believed to represent outliers of the Cretaceous, though it may be to some extent doubtful whether they should not rather be classed with those above described as conformably overlying the limestones of the Vancouver series.

Calcareous ash-rock with fossils.

A rock having a somewhat unusual appearance was collected at a point on the coast one and a half miles east of Cape Scott. Macroscopically, it had a granular character, and showed some evidence of stratification. It is of a dark greenish-grey colour and is blotched with leek-green patches of some chloritic mineral. This rock proved, on microscopic examination, to be an evident volcanic ash, containing angular fragments of orthoclase and triclinic felspars, not much decomcomposed, together with calcite and chloritic matter. Organic remains are further distinctly visible in it, consisting of pieces of crinoidal columns and one fragment which is apparently part of the spine of some echinoderm. Taken in connection with the interbedding of limestones and volcanic material previously described, this more intimate mingling of the same classes of materials is a point of interest, which could not have been determined by any superficial examination of the rock, and was not even suspected till it was placed beneath the microscope.

Terraces.

In some of the bays along the shore of Vancouver Island, between Shusharte and Cape Scott, there are terraces of sand and gravel deposits about fifty feet in height, but no true boulder-clay was seen in these. Iron ore, and iron sands containing gold, have been reported on this part of the coast, but on insufficient evidence. On the sandy beach of the bay east of Cape Commerell, and elsewhere, magnetite sand occurs in the form of layers a few inches thick, on the beach, but is not in sufficient quantity to be of economic value. The gold which has been reported doubtless occurs in this, as 'colours' can be

Reported iron and gold.

found in almost any magnetic sand along the shores of the island, though in washing a small quantity of the sand from this place, none were actually met with. In the Vancouver Island Pilot* p. 175. Nahwitti or Nawitti Bar is is said to be a ledge of "sandstone formation," but as no part of the bar is exposed at low water and no sandstone is seen on the adjacent shore, I am at a loss to know how the facts as to its composition have been obtained.

Low land.

The low character of the country, for a long way back from this part of the coast, affords reason for the belief that there is here a considerable body of land which may eventually be utilized for agriculture. There is also probably a considerable quantity of good timber in this low tract, though that seen near the shore was wind-shaken and inferior. Having heard reports of a lagoon with open grass lands running across to the east of Cape Scott, I delayed long enough to visit it. It is reached by a trail, from the bottom of the bay five miles east of Cape Scott, and also by a second trail, three miles east of the same point. By the last mentioned trail, it is distant from the shore about half a mile, the intervening country being low and thickly wooded. The lagoon opens in a bay, three and a half miles south of Cape Scott, on the west coast, and when afraid to pass round the cape—which in bad weather is much dreaded—the Indians occasionally portage their canoes to the lagoon for the purpose of reaching this coast. The lagoon, which is narrow, is bordered by muddy flats, a quarter of a mile or more in width and all subject to overflow at exceptionally high tides. They are well covered with coarse grass, and a considerable area might be reclaimed for agriculture by dyking the mouth of the lagoon, which would not be a very difficult operation. Further inland, on streams flowing to the lagoon, the Indians report somewhat extensive open, grassy flats, which are resorted to by the elk or wapiti. The Indian name of the lagoon is Kī-kī-tlum or the "grassy place."

Lagoon.

Scott Islands.

Cox, Lanz, East and West Hay-cock, and Triangle islands, which together with several smaller rocks from a chain running in a westward direction from Cape Scott, for about thirty miles, were not visited. It is indeed only under the most favourable circumstances that they can be reached by canoe or boat on account of their extremely exposed position.

Cape Scott to Quatsino Sound.

Cape Scott.

The rocks of Cape Scott and of the west coast southward to the western mouth of the lagoon (Na-kum-kilis of the Indians), essentially resemble these of other parts of the Vancouver series, being chiefly amygdaloids, with quartz filling, well bedded ash rocks, and compact felsites, but differ in the prevalence of reddish tints and in

* Admiralty, London, 1864.

their often less highly altered appearance. The general dip is about W. $< 30°$, and the whole series is much shattered by jointage-planes and cut by innumerable little dolomitic veins, which weather to bright yellow tints. The appearances tend to show that the volcanic rocks have here been changed and reddened by hydrothermal or solfataric action.

From the last locality southward to Sea-otter Cove, the rocks are generally similar in character, and have at first a similar attitude. The strike, however, before reaching Cape Russell, turns more to the east, and the rather massive beds are affected by flexures, dipping sometimes to the northward and sometimes southward. Near Cape Russell, reddish tints are not so prominent, and reddened portions of the formation were here observed to be irregular and not conformable with the strike, thus affording evidence that the reddening is often, if not in all cases, due to subsequent action. Dolomitic veins are uniformly abundant in the reddened rocks. Cape Russell.

On the east side of Sea-otter Cove are blackish Monotis shales, containing intercalated thin beds of amygdaloid, and becoming interbedded at one end of the section with tufaceous layers, some of which resemble ordinary sandstone in appearance, and are associated with beds of fine agglomerate and lenticular limestones—the whole proving, in the most conclusive way, the inter-relationship of the volcanic rocks and the argillites. Tufaceous rocks, like these here described, were seen in the bay north of Sea-otter Cove, and the associated argillites are doubtless there concealed beneath a low beach. From Sea-otter Cove southward, the argillites and tufaceous rocks run across the narrow neck which separates the cove from San Josef Bay and are again seen on the continuation of the same line of strike in the middle of the south shore of the bay, where they appear to run out in a series of shallow folds on the volcanic rocks. This outcrop of the argillites may thus be said to be traceable continuously for about four miles, but the observed dips were so conflicting that it was impossible to determine their position relatively to the volcanic rocks flanking them on both sides. It appeared most probable, however, that they form an irregular anticlinal, which runs to the southward, the small cove just inside the south entrance of San Josef Bay being again occupied by the argillites, with westward dips. In this case, a rough-weathering agglomerate, which occupies the intermediate portion of the shore of the bay, would underlie the argillites, while the reddish felspathic rocks of the south entrance point and of the vicinity of Cape Russell would overlie them. Sea-otter Cove. San Josef Bay.

From San Josef Bay to Cape Palmerston, and thence to Raft Cove, the shore is continuously occupied by altered volcanic rocks, partly Cape Palmerston.

reddened and in part of the usual greenish and blackish colours. Some of these are evident agglomerates, while others are massive felspathic materials of uncertain origin. All the rocks along this part of the coast are terribly shattered by pointage-planes—so much so, indeed, that it is often almost impossible to break out a shapely hand specimen.

Raft Cove.

On the north side of Raft Cove, near the entrance point, flaggy argillites, rather greyer than usual in colour, and associated with agglomerates and other volcanic materials, again appear, with a very regular strike S. 30° E. and north-eastward dip at angle of 60°. Resting upon these, just at the north entrance point, is a small isolated patch of greenish sandstones, unconformably superposed and full of rounded pebbles of the volcanic rocks of the Vancouver series. Some layers contain masses of *Aucella Piochii*, proving the identity of horizon with the Aucella sandstones of Quatsino Sound, subsequently mentioned.

Cretaceous outlier.

Raft Cove to Quatsino Sound.

From Raft Cove southward to Quatsino Sound, a distance of eleven miles, the rocks of the coast, though closely examined, presented no new features requiring special mention. Though considerably flexed and with rather irregular dips, the shore appears in the main to follow the strike. The materials are entirely volcanic in origin, with greenish, greyish, blackish and reddish tints, and vary in texture from agglomerates to fine-grained felsites, some of which are reddish and slightly porphyritic. Considerable beds of amygdaloid are also included in the series. The shore is almost uninterruptedly compsed of solid rock, forming a rough, iron-bound coast-line, which only at rare intervals shows a little creek or cove capable of affording shelter to boats or canoes.

Lithological characters of specimens.

A few typical rocks of the Vancouver series, selected from those collected on the west coast between Cape Scott and Quatsino, were subjected to a preliminary miscroscopical examination, with the following result:—

No. 360. Three and a half miles south of Cape Scott. A dark brownish-red, minutely porphyritic, compact rock. Proved to be a felsite, the porphyritic felspar being orthoclase.

No. 360 *b*. Same locality as above. A purplish-grey, rather slaty rock, with minute green spots. This is a fragmental, felspathic rock, much decomposed, and containing a quantity of some green chloritic mineral.

No. 362. Coast five miles south of Cape Scott. A dark reddish-brown, compact rock. This is a finely porphyritic diabase, considerably decomposed, and might be classed as a melaphyre.

No. 387. Coast one mile north of Top-knot Point. A dark brownish-grey, distinctly porphyritic rock. This is a felsite, the porphyritic felspar being orthoclase in Carlsbad twins.

No. 390. Coast two miles south-east of Top-knot Point. A greenish-grey, speckled rock, of rather pale tint, is too much decomposed for recognition, but is chiefly formed of decomposed felspar, with chloritic matter.

The distance from Cape Scott to Quatsino Sound is twenty-six miles, the general direction of the coast being nearly straight, and running north-north-west by south-south-east. It is indented by a number of bays and coves, but the only one of these which constitutes a passable harbour is Sea Otter Cove, and this, in consequence of its narrow opening with a number of rocks near it, and the strong tidal currents running past it, would be difficult of entry by a vessel without steam-power. This whole coast is much bolder in character than that to the east of Cape Scott, and in most places rises steeply from the water's edge, into hills, many of which exceed 1000 feet in height. These are generally densely wooded, but bare, dead trees are seen in great abundance almost everywhere, standing among those which are still living. This is not the result of forest fires, but is probably caused by the very heavy storms to which this unprotected coast is subject, in consequence of which, also, most of the timber is stunted and crooked. Further inland, and particularly in the valleys which must exist there, timber of a much better character is doubtless to be found. The coast is, in some places, fringed with low, rocky reefs, which extend far seaward, and upon which the long swell of the Pacific never ceases to break with fury. Behind these are generally sheltered nooks, known to the Indians, into which canoes can be run safely, even in heavy weather. Other parts of the shore, not protected by such fringing reefs, are cut into pillars and 'stacks,' or the cliffs are arched out by the sea into caves and grottoes. A shore of this character generally presents numerous little sandy or gravelly beaches, most of which are, however, exposed to the full force of the sea. Larger stretches of sandy or gravelly beach, are found in San Josef Bay, Raft Cove, Open Bay, and elsewhere. No permanently occupied Indian villages are now to be found on this part of the coast, though several old village sites were observed, and there are rude huts at one or two places, to which the natives resort for halibut fishing.

General character of coast.

Quatsino Sound.

This inlet, which is the north-westernmost of those by which the outer Coast of Vancouver Island is dissected, is also one of the longest, and most complicated in outline. It penetrates the island in an easterly direction for over twenty-five miles. The description of its dimensions and form, given in the Vancouver Pilot, 1864, p. 242, can scarcely be

General description.

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improved on for brevity, and is as follows:—"The breadth at the entrance is nearly six miles, narrowing to less than a mile at five miles within; the sound then runs in a north-easterly direction, (mag.) nearly straight for thirteen miles, when it branches off in two arms, one extending to the south-east for twelve miles, and terminating in low land; the other arm lies to the northward of, and is connected with the Sound by a straight, narrow pass, [Quatsino Narrows] about two miles long; its length is twenty-two miles in an east and west direction, and the eastern extreme, Rupert Arm, is only six miles distant from Hardy Bay on the north-east side of Vancouver Island; the western part terminates within twelve miles of San Josef Bay on the outer coast. Just within the entrance of the sound, on the north side, is Forward Inlet, about six miles long in a northerly direction, in which are the best anchorages of the sound."

Character of shores.

The shores of Quatsino Sound are in general rocky and bold, with mountains or high rocky hills, rising steeply from them. There is, however, a somewhat greater extent of sandy and gravelly beach than occurs in most of the inlets of the coast, and the mountains are not so closely crowded together as in many parts of Vancouver Island, there being considerable intervening tracts of lower land, and wide valleys of which the terminations are not known, running back from its shores. Somewhat extensive areas of low country border the shores of Winter Harbour, at the head of Forward Inlet, and a wide tract of country characterized by low rounded hills, exists on the south shore of the main inlet west of Limestone Island, while other important low areas are found near Hecate Cove, Coal Harbour and Rupert Arm. The quantity of good timber on these must be very considerable, and toward the upper part of the sound, the Douglas fir—which is not seen along the outer coast of Vancouver Island—re-appears.

Indian villages.

Forward Inlet is the particular territory of the Quatsino or Kwat-si-no tribe, whose village is on the east side, opposite Robson Island. A second village which these people inhabit at certain seasons, is near the head of Winter Harbour, and is named Tē-nā-ate. The present Koprino or Keaw-pēno village is on the east side of the harbour of the same name. It is known as Ten-as-kuh ("plenty cedar-bark,") and is the old summer village of this tribe. The site of their old winter village, now abandoned, is five and a half miles further east, and is named Bēce. These people have, however, now almost ceased to maintain their existence as a separate tribe. The main village of the Koskeemo or Kōs-kīmo tribe, known as Whatē-ēs is at Turn Point, at the entrance to Quatsino Narrows. These people have also a summer village opposite Koprino Harbour, where indicated on the charts, which is named Mā-ātē. There are, besides these, several other abandoned village sites in different parts of Quatsino Inlet.

Forward Inlet.

The shores of Forward Inlet are chiefly composed of rocks of the Vancouver series, but in part also of Cretaceous sandstones. On the east side of Robson Island, and on the shores of the point to the north, which separates the main inlet from Browning Creek, there are extensive exposures of the flaggy argillites, which, though much crumpled and confused, and penetrated by a number of grey felspathic dykes, appear in the main to assume an anticlinal form, overlying a greenish-grey compact volcanic rock, and being overlaid by agglomerates, which are often well bedded, and sometimes have a rather tufaceous appearance. The argillites themselves present their usual black flinty appearance with regular and thin bedding where undisturbed, and are frequently more or less calcareous. The general strike of these and the associated altered volcanic rocks, is about north-west by south-east, but there are, doubtless, several folds and possibly other complications, as the argillites recur at two places on the shore to the east of, and opposite, the point above mentioned, and also at two places on opposite sides of Winter Harbour, further up the inlet. The exposures of these argillites in Forward Inlet afforded a considerable number of specimens of the *Belonites*, for which Mr. Whiteaves, in the appendix, proposes the name *A. Vancouverensis.*

Triassic argillites.

Cretaceous rocks of Browning Creek.

The altered volcanic rocks here present no unusual characters and do not require special description. One of the Cretaceous outliers above referred to, occurs at the head of Browning Creek, at the middle of the west shore of the expansion in which this branch of the inlet terminates. It is a very small patch of greenish-grey sandstones, not more than fifty yards wide. The beds dip N. 75° E. $<$ 25° at the south-east, and about N. 20° W. $<$ 30° at the north-east of the exposure. The sandstones rest on reddish-weathering hard felspathic rocks of the Vancouver series, of which they include rounded pebbles. Some layers contain great numbers of shells of *Aucella Piochii*, together with a few other fossils. Specimens collected at this place by me in 1878, have been figured and described by Mr. J. F. Whiteaves. (Trans. Royal Soc. Can. Vol. I., sect. iv., p. 81.)

Cretaceous rocks of Winter Harbour.

A second, and much more important Cretaceous outlier, is that which surrounds the upper part of Forward Inlet, known as Winter Harbour and appears, on both shores, to the exclusion of other rocks, for a mile and a half from its head. The rocks are here again chiefly greenish-grey sandstones, but also include layers of conglomerate, and hard, fine-grained, calcareous beds, more or less nodular in character. The dips are generally northward, at angles of 60° to 5°, and the beds appear to form an ascending series of considerable thickness, of which layers characterized by a great abundance of *Aucella* and other fossils form the lowest visible member. Local irregularities in dip and other cir-

cumstances lead to the belief that the beds have not alone been affected by folding, but that faults also exist, and as the land is rather low and densely wooded on both sides of the inlet, the form and dimensions of the Cretaceous area of this place have not been determined. To the north-eastward, it extends to the lower end of the lagoon, which opens from the head by Winter Harbour, but on the channel connecting the lagoon and the harbour, there is a projecting mass of the older volcanic rocks. The lagoon itself (known as Huh-nish by the Indians), was examined by me in 1878, in consequence of the reported existence of coal upon it. So far as the small rock-exposures show, its shores are chiefly composed of altered volcanic rocks. The coal was found to occur upon a small creek or stream at the upper south-west angle of the lagoon, the exposures being at about forty yards from high-water mark. The beds are nearly vertical, and a couple of small holes had been sunk upon them, the first showing—coal, apparently of good quality, 1 foot; shale 1 foot 6 inches; coal, partly impure, 1 foot; shale and coal, 2 feet 6 inches; carbonaceous shale, 2 feet. The second hole, at a distance of thirty feet across the measures, shows about 3 feet of coal and shale intermixed, followed by carbonaceous shale and this again by a pale clayey material. The area of the coal-bearing rocks is here, apparently, quite small, and they are so much disturbed, that even if the seams were of a more promising character, this would not be a suitable place for work.

Lagoon.

Coal outcrops.

Position of coal

With the exception of the place just described, no coal was seen in the Cretaceous rocks of any part of Forward Inlet. There is reason to believe that the coals seen at the head of the lagoon occupy a horizon near the base of the Cretaceous series, and that they might be found by boring through the less disturbed Cretaceous rocks of the vicinity of Winter Harbour, possibly in greater thickness.

Thickness and composition of Cretaceous.

In addition to the Cretaceous outliers seen in Forward Inlet, there are probably numerous others of the same kind yet to be found inland from it, and the extension of the Winter Harbour area to the northward may he considerable. Mr. Dowling examined a small stream known as the Zenaad River for about a mile from the shore in a northward direction, without reaching the limit of the Cretaceous. A number of circumstances appear to establish a probability of the existence of an important fault, with downthrow to south-west, which may run nearly parallel in direction to the lagoon, passing near the head of Winter Harbour. The probable thickness of the Cretaceous series from the southern outcrop to the head of the harbour, is about 3600 feet, the highest rocks seen, at the head of the harbour, being rather massive conglomerates. Similar conglomerates are again seen a short distance up the Zenaad River, these rocks probably being in both cases to the

south-west of the fault. These conglomerates are supposed to be identical with those forming the upper number of the series in the Koprino area, subsequently described, and as sandstones resume further up the Zenaad River, with regular low dips to the northward, or north-eastward, it is quite probable that the upper part of the range of high hills, rising above this part of the river, which is continued in a south-eastward direction to the east of the lagoon, may prove to be composed of the same massive conglomerates, coming in again at a higher level in consequence of the fault. In this case the Carbonaceous area may extend some miles to the north. The whole question of the inland extent of the Winter Harbour and Koprino Cretaceous areas deserves examination, but would require two or three weeks of work in the bush.

In addition to *Aucella Piochii*, which has already been referred to as filling entire beds, both on Browning Creek and Winter Harbour, *Scaphites Quatsinoensis* is found in both the above localities. On the south side of Winter Harbour, in addition to the *Scaphites*, the fossiliferous nodules have yielded a *Cinulia*, a *Dentalium*, fragments of an *Alaria*, the cast of a small *Protocardium*, an *Astarte*, like the supposed *A. Packardi* of the Queen Charlotte Islands, a *Yoldia*, an *Arca*, and a few scattered bones of some teleostean fish. **Fossils.**

The north shore of Quatsino Sound, from Forward Inlet to Koprino Harbour, exhibits a great series of the altered volcanic rocks of the Vancouver series. These show persistent south-westward dips, at angles of from 35° to 60°, but are probably repeated either by folding or faulting, as the thickness indicated would otherwise be enormous. The materials are principally agglomerates, of greenish or grey tints, but occasionally, conspicuously red in colour. Amygdaloids also occur, but do not form so important a part of the whole. These rocks have been subjected to somewhat less alteration than usual, and the agglomerates frequently weather out into rough surfaces, with a scoriaceous appearance. The rocks of the south shore of the inlet, from Bold Bluff to the west side of Koskeemo Bay, of the chart, are similar, with similar dips. The west side of Koprino Harbour is composed of similar greenish rocks, probably agglomerate, but on the east side of the north-west cove, a massive grey limestone, with a minimum thickness of about forty feet, appears, and is associated with hard sandstones and flaggy argillites of the same series, considerably disturbed and irregular. Beyond the next little cove, or creek, to the east, the rocks of the shores and Islands of Koprino Harbour, belong entirely to the Cretaceous series, of which some details are given below. The abutting of the strike of the Cretaceous rocks of Plumper Island, in the centre of the harbour, on the green rocks of its west side, with other circumstances, give evidence of the probable existence of an important fault, **Forward Inlet to Koprino Harbour.**

with a course of about N. 15° E., and downthrow to the eastward. The same fault appears to run across the inlet, and to cut into the south shore, just east of the end of the larger island in Koskeemo Bay, of the chart. There is here a small tongue of Cretaceous sandstone, with irregular dips, which is presumed to be in contact with the fault to the east.

North shore of inlet east of Koprino.

From the east side of Koprino Harbour, for a distance of some miles, or to a point opposite the middle of Limestone Island, Cretaceous sandstones and conglomerates occupy the shore, forming a part of what may be called the Koprino Cretaceous area. Thence to Hecate Cove, the altered volcanic rocks are again met with, with westward dips, at angles of 30° to 45°. These rocks run across to Limestone Island to the south, of which they form the greater part. Bluish and grey limestones, however, which conformably underlie these volcanic materials, outcrop along the east shore of the island, and in a small islet off it, were found to contain silicified corals in considerable abundance. Of these, Mr. Whiteaves states that one form resembles *Thamnastræa*, while a second is probably an *Astrocenia*. They are probably not older than the Trias, and might be newer.

Fossil corals.

South shore of inlet.

Similar agglomerates and amygdaloids compose the south shore of the inlet, south of Limestone Island, with the exception of the east side of Banter Point of the chart, where a small outcrop of limestone again occurs. Altered volcanic rocks, of the same general character, and with similar persistent westward dips, form the greater part of the entire south shore of the inlet eastward to Village Islands, opposite Koprino Harbour, together with Brockton Island. On the east side of Village Islands, the flaggy argillites re-appear, overlying well-bedded, fine-grained, felspathic rocks. The exceptional points on this shore consist of small outliers of Cretaceous sandstones, which may be regarded as portions of the southern edge of the Koprino Cretaceous area previously alluded to. The largest area of these rocks extends along the coast between Limestone and Brockton islands, for nearly two miles, with low dips generally off shore. The rocks are greenish-grey sandstones, and may extend for some distance to the south, as the land in that direction is all low. The exposures at the east end of this area show the sandstones passing into conglomerates, and in actual contact with the older volcanic rocks, filling hollows and crevices in their surface, which has been very irregular.

Cretaceous outliers.

In these outlying patches of Cretaceous, on the south shore, obscure impressions of plants were frequently seen, together with casts of a small *Lima* and of ammonitoid shells. The small islands in the deep bay between Brockton and Village islands, represent a second outlier of similar sandstones, some of which contain fragments of *Inoceramus*.

They dip regularly off shore, at angles of 10° to 20°, the strike running round parallel to the shore of the bay.

Koprino Cretaceous area

The shores of Koprino Harbour, and the islands in it, afford a number of excellent exposures of the Cretaceous sandstones and conglomerates, but the dips and strikes of these are so extremely varied and irregular, that a minute survey of the whole would be required before any definite conclusions could be drawn as to their exact relations. It is highly probable, however, that the section is here complicated by one or two faults, one of which may possibly be continuous with that previously referred to, as probably running parallel with the lagoon of Winter Harbour, on Forward Inlet. A coal-seam was reported to exist in the vicinity of Koprino, but on obtaining an Indian to guide me to it, I found that it was the same coal occurrence which has already been described at the head of the Winter Harbour lagoon. This is reached by a trail from Koprino, in less than two miles.

Cretaceous on north shore of inlet.

The Cretaceous rocks, of that part of the Koprino area which extends from the east entrance point of the harbour, for at least seven, and probably, for eight miles, along the north shore of the main inlet, are throughout, pretty regular and not much disturbed. They consist chiefly of conglomerate and sandstones, the former frequently producing bold bluffs and hills along the coast, which in the main, very closely follows the strike. The beds dip inland, the direction varying generally but a few degrees on either side of north, though one or two rather sudden changes of strike were observed locally. The angle of inclination varies, as a rule, between 10° and 20°. Beneath the massive conglomerates, which must have a thicknsss of at least several hundred and possibly of 1000 feet or more, are softer sandstones, which often occupy the beach. Near the last exposures to the east, (opposite the west end of Limestone Island) the beds take on a light eastward dip, but probably dip westward, at pretty high angles, further east, as, after a concealed interval of about a mile, the underlying altered volcanic rocks appear, terminating the possible extent of the Cretaceous basin in this direction.

Ten-o-suh River.

As affording a means of examining the inland extension of this Cretaceous area, the Tĕn-o-suh River, which flows into the north-east angle of Koprino Harbour, was followed up for about three miles. This stream is quite a small one in the autumn, but from the size of its bed, and the inextricable log-jams with which it is filled, must be a formidable torrent at some seasons. The exposures seen along it were rather few, but appeared to indicate an anticlinal, followed by a light synclinal. The rocks are sandstones and conglomerates, without distinctive features, and no trace of coal was observed, nor was the northern edge of the Cretaceous basin reached. The Indians, by fol-

lowing this river to its head, and then descending the valley by a second small stream, reach the West Arm, at a place nearly opposite the Nookneemish River.

Composition of series.

It may, I think, be assumed with considerable certainty that the massive conglomerates so largely developed in the Koprino area, are equivalent to those of which the base is seen forming the highest beds in the Koskeemo Cretaceous area, subsequently described. They are probably also identical with those seen at the head of Winter Harbour, forming the highest member of the Forward Inlet Cretaceous. The greater part of the comparatively soft sandstones shown in the lower parts of the sections in both these areas is doubtless now covered by the water of the main inlet east of Koprino Harbour, thin selvage edges only appearing in a few places on the south shore, as before noticed. By assuming an average angle of dip for the measures, the thickness of the beds underlying the conglomerates, and for the most part beneath the inlet, would appear to be at least 2,000 feet, and it may be much greater. This is somewhat less than the estimated thickness of the same part of the section of Forward Inlet, and greater than that taken as a minimum for the same beds in the Coal Harbour area.

Beds overlying conglomerates.

The only locality in which beds pretty certainly overlying the conglomerate portion of the series were seen, was in a small island in Koprino Harbour, opposite the East Cove. These are grey, finely fissile, rather hard and very regularly bedded shales, quite different in appearance from any other rock seen about Quatsino Sound. These are at angles of 60° to 80° in the centre of a small synclinal and conformably overlie massive conglomerates to the south, though in contact with an intrusive rock to the north. The exposed thickness is probably over a hundred feet. No fossils were obtained from these beds, but they closely resemble the Upper Shales, which are found overlying the conglomerate member of the Queen Charlotte Island Cretaceous series. (See Report of Progress, Geol. Surv. Can., 1878-79.)

Probable importance of Koprino area.

It appears quite probable that the Cretaceous basin, here spoken of as the Koprino area, may prove to be the most important, from an economic point of view, of those of Quatsino Sound. It is much larger than any of the others; the regularity of its beds to the east and north of Koprino Harbour is great, and it is more easy of access than the Coal Harbour area, to reach which, the Quatsino Narrows must be passed, which can only be done at favourable stages of the tide. The circumstances being such, it would seem to be a quite legitimate (though it must be admitted, in the present state of our knowledge, a purely speculative) enterprise to test this area for coal, by

boring at some favourable point or points near the shore to the eastward of Koprino Harbour. Such an enterprise, should, as a matter of course, be preceded by a thorough examination of all parts of the surface of the area, which would be somewhat laborious, on account of the thick and tangled character of the forest growth.

In all attempts to determine the character of this and other Cretaceous basins of the vicinity by an examination of the natural outcrops, it must be borne in mind that, as before stated, they probably fill pre-existing hollows in the surface of the older rocks, upon which they progressively overlap. The circumstances requiring consideration in this connection are more fully stated in the preliminary pages of the report.

The south-east arm of Quatsino Inlet, clearly follows the general strike of the rocks of the Vancouver series, and occupies a depression which has been worn out along the outcrop of the same bed of limestone, which is noted in connection with Quatsino Narrows and the east end of Limestone Island. The beds dip in general south-westward at high angles all along the arm. Limestone is frequently seen along the east shore, and appears to rest on a green amygdaloid. At Long Island, near the southern extremity of the arm, there are large exposures of flaggy argillites, which follow the limestones in ascending order and are often more or less calcareous. Obscure casts of *Monotis* or *Halobia* were seen in them in a few places. Further exposures of these argillites are found skirting the west shore of the arm nearly to its north end. The argillites are overlain by dark greenish agglomerates. Copper-stained greenish rocks were observed in several places on this arm, but appeared to result merely from the weathering of small quantities of copper pyrites, in or near felspathic dykes, which cut the other rocks, and are of no importance. No Cretaceous rocks were seen on this arm. **South-east arm.**

The existence of the transverse hollow now occupied by Quatsino Narrows, is pretty evidently due to the softer character of a thick bed of limestone, which nearly follows the course of the narrows. A second bed, or possibly a repetition of the same bed, runs across a low country from Hecate Cove to the south shore of the West Arm, parallel to the first. The same limestone appears on the opposite side of the West Arm, in large exposures to the west of Hankin Point. The Cretaceous rocks of the vicinity of Coal Harbour, which may be designated the Koskeemo area, occupy the northern shores of the West and Rupert arms, for some miles on each side of the promontory of which Hankin Point forms the apex. This coal-bearing area is treated separately below, in some detail. The shores of the West Arm were examined by me in 1878, to within three miles of its extremity. Two very small selvages of Cretaceous sandstone were found on the **Limestones.** **Cretaceous areas.**

north shore, beyond the main Koskeemo area,—the first five, the second six and a half miles west of Coal Harbour. The rocks had rather high dips off shore, or to the southward, but whether they represent small portions of the Koskeemo area which come in to the north of a continuation of the main fault, subsequently described, or indicate the position of Cretaceous rocks which may have filled a pre-existing hollow now occupied by the West Arm, I was unable to decide. The remaining rocks seen along the West Arm, belong to the Vancouver series, and are largely of the usual altered volcanic materials. A persistent bed of limestone, however, which is associated with these rocks, runs along the south shore for several miles, with a general southward dip.

Rupert Arm. The rocks of Rupert Arm, with the exeeption of the Cretaceous previously alluded to, are generally reddish or grey felspathic materials, of somewhat doubtful origin, but referable to the Vancouver series. Limestones again outcrop at the points to the east of the entrance to Quatsino Narrows. All the western part of the south shore of this arm shows no rock exposures, and from the low character of the country, it is possible that the Cretaceous rocks of the Coal Harbour area are continued in this direction.

Koskeemo Cretaceous area. The area of Cretaceous rocks on the north side of the West and Rupert arms of Quatsino Sound has attracted considerable attention, and several praiseworthy attempts have been made to prove and develop its coal-bearing character. The latest of these has been carried out by the West Vancouver Commercial Company, who executed various borings and other operations, at intervals from November, 1883, to May, 1885. Having been supplied with copies of the drill records obtained, through the kindness of Mr. J. Preston Moore, a somewhat detailed investigation of that part of the district in the vicinity of Coal Harbour and the Nookneemish River was undertaken, including paced surveys along the shores and between the several points at which borings had been made, and extending inland on the Nookneenish and tributaries of the Natzinughtum to the northern edge of the Cretaceous area. A general examination of the shores had already been made by me in 1878, but the somewhat fragmentary information then gained had not been published.

Limits of the area. Though the northern edge of the Cretaceous basin has not been continuously traced, it has been defined at four points, viz., at its two extremities on the shore, and at two intermediate places where it crosses the streams above named or their tributaries. By joining these, with due regard to the observed dips and strikes of the rocks, it may be assumed that a fairly correct outline of the basin on this side is obtained, the Cretaceous rocks there resting unconformably on, and dipping re-

gularly southward from, those of the Vancouver series. To the south, the basin is cut off by a fault, with an extensive downthrow to the north, and a course of about N. 89° W. The throw of this fault must exceed the entire exposed thickness of the Cretaceous of this basin, which is at least 1500 feet. To the westward, it runs past the mouth of Coal Harbour, cutting into the shore near a small cove, a mile and a third beyond the west entrance point of the harbour. It then crosses the bay at the mouth of the Nookneemish River, again cutting the shore a mile beyond the mouth of that stream. Eastward, it must cut the west shore of Rupert Arm, about two miles from its head, and as the shore in the intervening stretch is all low, it is possible that the rocks of the Cretaceous series here re-appear, and continue for some distance eastward. Still further in this direction, the fault appears to run completely across the island to Port McNeill and beyond, as explained on p. 64 B. The rocks to the south of the fault, which form Hankin Point, are massive, greenish amygdaloids, overlain by a thick bed of limestone, which forms low cliffs near the east entrance point of Coal Harbour, and re-appears in the cove at the east side of Hankin Point. On both sides of the bay into which the Nooknemish flows, the older rocks to the south of the fault are hard, shattered, rusty quartzites, and greenish and purplish felspathic materials, sometimes evidently altered agglomerates.

Great fault.

The total length of the Cretaceous area thus outlined, from east to west, is seven miles; its greatest probable width about two miles, and its approximate probable area—without including under-water extensions—about 5630 acres. So far as I have been able to ascertain, its rocks comprise a series of sandstones, shales and conglomerates with general southward dips, generally at angles of from 10° to 30°, complicated only by one slight synclinal flexure, which runs nearly east-and-west across the northern part of Coal Harbour. When immediately in contact with the great fault, near the east entrance point of the harbour, the beds are much disturbed, and for a few yards assume a very steep northward dip. It must be stated, however, that in consequence of the thickly wooded, and drift-covered character of the land and the want of continuous sections on shore, numerous minor dislocations might occur without affording any evidence of their existence.

General character of rocks.

The nearest approach to a complete section of the basin, is obtained on the west side of Coal Harbour, and in the vicinity of the road or trail which has been cut in a northward direction from the harbour, and by which the sites of the more important borings and prospecting openings are reached. An examination of this section leads to the belief, previously alluded to, that the entire thickness of the Cretaceous series here shown, is from 1300 to 1500 feet. An attempt has been made to

General section.

formulate a general vertical section of the measures by bringing together all the facts afforded by the natural exposures, and those obtained in the borings, in the vicinity of the line of section above defined. It has been found, however, impossible satisfactorily to accomplish this, in consequence of the almost complete absence of well marked zones or beds with distinctive characters which might serve as planes of reference. Shales, sandstones, and more or less, conglomeritic beds, together with numerous thin seams of coal and coaly streaks, are met with in comparatively thin alternating layers throughout all parts of the series, and the character of individual beds appears to vary from point to point in different parts of their extent, to a perplexing degree. It seems pretty certain, however, that the highest exposed part of the formation is largely composed of massive conglomerate, of which only the lowest beds probably remain, and which are exposed in the light synclinal which crosses Coal Harbour, and again on the east side of the harbour, to the north of the fault.

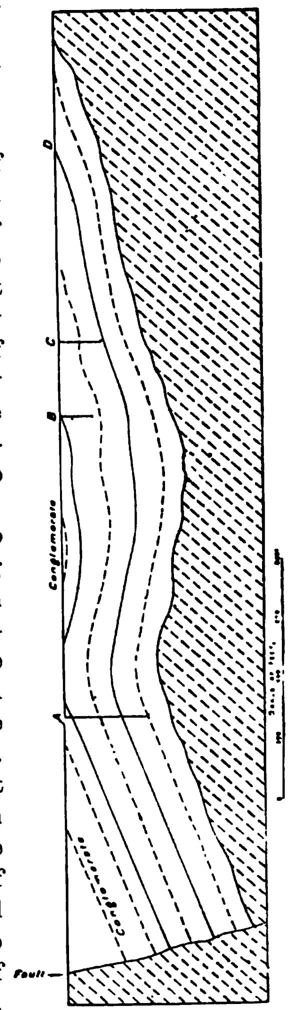

FIG. 2. DIAGRAMATIC SECTION OF COAL-BASIN. WEST SIDE OF COAL HARBOUR. DIRECTION, SOUTH TO NORTH.

Coal-bearing horizons.

At a probable depth of from 200 to 300 feet below these, is a coal-bearing zone, of which the outcrop appears on the shore of the west side of the harbour, to the south of the axis of the light synclinal, with a north-westward dip at an angle of 25°. There is here about two feet of coal of fair quality. The westward extension of this light synclinal is not known, but its northern edge, not far from the horizon of the coal, should pass near the position of boring B, on the plan, and the coal which is reported to outcrop near the mouth of the Natzinughtum, (but of which I saw only detached fragments), is probably the continuation of the northern outcrop of the seam just mentioned. It is, doubtless, also the same seam which was reached in boring E, near the mouth of the Natzinugtum, at a depth of twenty-eight feet, and reported to be 5 feet 4 inches in thickness, but of poor

quality. The same seam is again supposed to be represented by the outcrop on the shore two and a quarter miles north-eastward from Hankin Point. It is here separated into three parts, the two lower of 6 inches each, the upper of 1 inch, separated by several feet of clayey shales, and dipping S. 5° E. and 30°.

The second coal-bearing zone is probably from 400 to 500 feet lower in the series. It occurs, furthest west, a mile and a quarter beyond the mouth of the Nookneemish River, near the beach, where a small shaft has been sunk, and a few tons of coal extracted. The outcrop could not be seen, but was reported to show about 3 feet 6 inches of coal, of which, however, about a foot was of inferior quality. There are no exposures on the Nookneemish where this seam should cross, but it is probably the same which was struck in boring F, near the mouth of that river, at a depth of 217 feet. It is pretty evidently again the same which has been opened further east by a small slope about a mile due north of the west entrance point of Coal Harbour, at the point marked D. The seam is here reported to be from 2 to 3 feet in thickness, and is of good quality. No outcrop of this seam was found on the shore east of Hankin Point, but if my view of the structure of the basin is correct, it is probably that which was reached in the deep boring at A, at a depth of 456 feet, with a thickness of 6 inches only. The position of this coal-bearing horizon must be about 300 feet above the base of the Cretaceous rocks. **Lower coal-bearing zone.**

North of the opening last mentioned, a coal-seam of about 3 inches in thickness was observed. It is associated with hard flaggy sandstones and hard dark shales, which form the lower part of the formation, and appear to have been penetrated to some depth in the bottom of boring A. At the eastern extremity of the field, about three miles north-eastward from Hankin Point, on the shore, a considerable thickness of conglomerates occur in what here must be the lowest part of the series. These were not seen elsewhere in the same position, and this occurrence is somewhat anomalous. **North edge of basin.**

The particulars above given, in conjunction with the record of borings, will show that no coal-seams of satisfactory workable dimensions have yet been found in this area, notwithstanding the exploration of it, which has been carried out by boring and otherwise. While, therefore, not ignoring the fact that more important seams may yet be found here, I cannot concur with Mr. Robert Brown, in his exceptionally high estimate of the value of this field.* It must be admitted that the enterprise of the gentlemen who have attempted the development of this area, has so far met with results of **No thick coal seams yet developed.**

*See his Paper on Coal-fields of the North Pacific Coast. Trans. Edinburgh Geol. Soc., 1868-69.

a somewhat discouraging character. In opposition to these, however, it may be stated that the explorations have not been sufficient to exhaust the possibilities of the field. As I am aware that some test borings were made before those of which I have been able to obtain the records were executed, and of which no detailed logs appear to have been kept, I feel some hesitancy in advising as to further explorations by boring, should such be decided on. Judging merely from the facts at my disposal, and from the observed attitude of the strata, I should be inclined, however, to recommend the continuation of boring C,—the furthest inland boring to the west of Coal Harbour,—to a further depth of 350 to 400 feet, or to the bottom of the Cretaceous rocks. Should it, however, prove impracticable to resume boring in this hole, or difficult to do so, a new hole might be begun at about a quarter of a mile to the north, which would be expected to reach the bottom of the Cretaceous series at a depth of about 400 feet. My reason for particularly advising the further prosecution of boring C, is, that so far as can be made out, this hole terminated but a short distance above the probable position of the underground continuation of the seam opened at D, and work done there would serve, in the first instance, to prove the character of this seam at a point some distance from its outcrop. Should this additional work be carried out, the character of the rocks as a coal-bearing series, might be assumed to be pretty well tested.

Best mode of testing the area.

Analysis of coal.

Analyses given in Mr. Robert Brown's paper, already quoted, show that the quality of the Koskeemo coals is often very good. An analysis by Mr. G. C. Hoffman of the coal from the opening marked D., on the accompanying plan, shows the following result:—

Hygroscopic water	1·05
Volatile combustible matter	34·38
Fixed carbon	54·01
Ash	10·56
	100·00

This fuel produces a fine compact coke, and is scarcely acted on by a solution of caustic potash.

Fossils.

Few fossils were obtained from the Cretaceous rocks of this area, but so far as they go, they bear out the view expressed in the preliminary pages of this report, as to the position of the beds in the Cretaceous series. On the Nookneemish River, some casts of molluscs were found not far above the lowest of the Cretaceous beds. These represent a small *Trigonia*, and the shell named *Pleuromya lævigata*, by Mr. Whiteaves, in his report on the fossils from the Queen Charlotte Islands. Among some fossil plants collected near the west entrance point of Coal Harbour, Sir Wm. Dawson has recognized *Sequoia Reichenbachi*,

Heer, and a form near to, if not identical with, *Thinnfeldia arctica*, Heer. These two forms are found similarly associated in Spitzbergen, in beds which are supposed to be Cretaceous, but must be low down in that formation.

The detailed records of borings in the vicinity of Coal Harbour, and on the Nookneemish, are as follows, the letters by which they are denoted, referring to those placed on the accompanying plan and section:— Boring A. Coal Harbour.

Deep boring near "The Settlement" (A.)

	FEET.	INCHES.
Coarse grained sandstone	29	10
Seams of coal shale and clay	2	10
Hard sandstone, ending in black shale	14	0
Pipe-clay	8	9
Coarse-grained sandstone	15	8
Seams of shale and coal	3	6
Fire-clay	5	10
Seams of shale, slate and coal (all mixed)	15	9
Fire-clay, with small pieces of coal intermixed	6	10
Seams of shale and coal (all mixed)	6	0
Dark, smooth, greenish slate	12	9
Reddish shale and sandstone, mixed with coal	8	0
Sandstone, with occasional spots of coal	20	11
Hard, smooth, grey shale	11	10
Same shale, with seams of shale and coal	38	8
Bluish sandstone, with hard, black grains and occasional pebbles	28	6
Hard, grey slate, showing pyrites	4	0
Sandstone	9	4
Hard, blue clay	2	11
Bony coal and shale	5	5
Mixed clay and shale	3	7
Hard sandstone, with hard, black grains and occasional pebbles	34	9
Seams of slate, shale and coal	14	6
Same black-grained sandstone as above	5	0
Grey slate, with occasional spots of coal	31	0
Seams of slate, coal and sandstone	13	0
Hard, fine conglomerate	13	4
Hard, grey sandstone, with spots of conglomerate	12	0
Hard, fine conglomerate, same as above	18	6
Soft, coarse, yellow, sandstone	4	8
Bony coal and shale	3	6
Fire-clay, mixed with shale	5	4
Coal, same as above	0	6
Hard sandstone, with black grains	5	0
Hard, black pebble conglomerate	7	8
Mixed seams of shale and bony coal	9	3

	FEET.	INCHES.
Hard sandstone	3	11
Fine quartzite conglomerate (very hard)	13	5
Hard, fine-grained sandstone	5	6
Coal	0	6
Same sandstone as just above	10	0
Very hard, fine, black pebble conglomerate (same as above)	15	7
Black slate and shale, with streaks of coal	5	11
Same black pebble conglomerate	2	8
Dark sandstone, with occasional spots of conglomerate	32	5
Dark slate	6	8
Dark sandstone, with spots of conglomerate	3	8
Very hard, fine conglomerate	12	3
Reddish sandstone	5	0
Hard, black and white pebble conglomerate	15	7
Black, sandy shale, with occasional streaks of coal and abundance of gas	28	10
Hard, fine-grained sandstone	21	8
Hard, black and white pebble conglomerate	21	11
Sandy shale	14	9
Grey sandstone, hard and uniform	80	0
Hard, compact black slate	8	6
Conglomerate	2	0
Total	739	8

Boring B. Coal Harbour.

Boring, about two-thirds of a mile to the northward of the last (B.)

	FEET.	INCHES.
Fine, white and blue clay	26	4
Pebbly conglomerate	12	8
Coarse sand (like beach sand)	2	3
Mixed sandy shale and coal	1	9
Sandstone	6	9
Slate	3	0
Sandstone	7	0
Sandy shale and slate, and dark sandstone	21	4
Coal, of good quality, and fire-clay	4	6
Fine-grained sandstone	14	9
Sandy shale and slate	1	3
Sandstone, with occasional spots of conglomerate	89	11
Black, sandy shale and black slate	11	9
Sandstone	18	3
Mixed shale, slate, clay and coal	4	3
Sandstone 6′ 1″ and black, compact slate 5′ 1″	11	2
Dark sandstone 10′ 1″ and same black compact slate 6′ 8″	16	9
Hard, fine-grained, black sandstone	5	2
Same hard, black, compact slate	6	7
Hard, dark, brittle sandstone	9	7
Hard, black slate	0	4
Total	280	10

Boring about three quarters of a mile northward from first hole. (C.) Boring C, Coal Harbour.

	FEET.	INCHES.
Coarse sandstone	3	8
Shale and coal	0	4
Coarse sandstone, same as above	5	4
Slate	3	4
Very fine grained sandstone	10	0
Black, mucky clay, with pieces of coal	1	1
Mixed slate	9	8
Black sand	0	3
Same fine-grained sandstone as above	3	3
Black, sandy shale	3	0
Sandstone	4	0
Black slate	0	10
Soft coal	0	9
Dark shale mixed with coal	1	7
Very fine grained sandstone	1	1
Black, flinty sandstone, like chert	0	3
Silicious limestone	3	8
Same black, flinty substance	0	2
Black, sandy shale	3	2
Same silicious limestone	1	0
Hard, black slate	9	8
Hard, grey slate, in places sandy	26	5
Coarse-grained sandstone	18	2
Hard, black slate	8	0
Sandstone	15	9
Grey slat	3	0
Hard, grey sandstone	7	9
Coal, good quality	0	8
Shale	0	4
Sandstone	31	10
Slate	3	9
Same sandstone	6	10
Hard slate, with shell impressions	5	1
Sandstone, with two small streaks of coal	9	0
Same slate as above, with shell impressions	1	6
Hard, dark, brittle slate	42	9
Shale and coal	0	3
Some hard, brittle slate, as before	11	2
Layers of slate, sandstone and conglomerate	9	2
Mixed seams of coal, slate and clay	1	4
Bands of shale, coal, sandstone and conglomerate	5	1
Sandstone and sandy shale	10	3
Brittle, dark sandstone	10	2
Fine, brittle conglomerate	8	3
Hard, coarse-grained sandstone	3	0
Hard slate with white seams of flint and lime	4	1
Hard, black, sulphurous sandstone	5	0

	FEET.	INCHES.
Soft, grey slate	5	0
Fine conglomerate, slaty matrix	17	5
Reddish sandstone	4	0
Different coloured, sulphurous slates	22	6
Hard, flinty slate (white seams)	4	5
Total	368	0

Boring E, Coal Harbour.

Boring on the Wagstee, at bottom of Coal Harbour, east of mouth of Natzinughtum. (E.)

	FEET.	INCHES.
Coarse conglomerate	24	10
Coarse sandstone	3	0
Coal seam (poor quality)	5	4
Fire-clay	4	0
Sandstone, same as above	30	0
Dark conglomerate	24	4
Sandstone, with spots of conglomerate	49	8
Fine conglomerate	7	0
Hard sandstone	40	0
Total	188	2

Boring F, Coal Harbour.

Near this place, on the Natzinughtum, a hole was put down 709 feet, but no record has been obtained of it. It ended in conglomerate, and it is to be presumed that it did not cut any coal-seams of importance. The probable position of this hole is marked (F).

Boring G. Nookneemish.

Boring near the mouth of the Nookneemish River. (G.)

	FEET.	INCHES
Soft shale	5	7
Sandstone	149	2
Tough, white clay	9	6
Sandstone with occasional streaks of coal	43	7
Conglomerate	4	6
Dark, sandy shale	5	2
Good coal	1	0
Soft, sandy shale	4	0
Hard, dark, smooth shale	1	6
Soft coal	0	6
Pipe-clay	0	3
Hard, blue slate	0	6
Soft, dark sandstone	20	10
Sandstone, with streaks of slate and shale	43	8
Smooth, black slate	3	3
Very hard conglomerate	43	7
Light, bluish clay, with quartz chips	12	3

	FEET.	INCHES.
Hard, dark sandstone	14	5
Soft, sticky, dark-blue clay	2	0
Hard, light-coloured sandstone	5	1
Total	370	4

Glaciation and Superficial Deposits.

In previous reports of the Geological Survey on different parts of the province of British Columbia, numerous observations on the phenomena connected with the glaciation of the country are recorded, and the importance of this epoch in its geological history is illustrated. In several papers, published elsewhere,* I have treated the same subject in a more general way, and advanced such hypothesis as appeared to be warranted by the facts. Though not previously examined in detail, the glacial phenomena and surface deposits of the region covered by the present report, have already been described in general terms, in the papers above referred to. To these former general statements, the work of 1885 has added much in the way of detail, but it has not in any important way, modified the main conclusions there stated. Previous reports and papers.

Evidence was advanced, in my paper published in the Quarterly Journal of the Geological Society for 1878, to show that the whole Strait of Georgia was at one time occupied by a great glacier, which had, in some places, a width of fifty miles, and attained a minimum thickness of 3000 feet in its northern part, and of about 700 feet at the south-east extremity of Vancouver Island, near Victoria. In a subsequent paper, I was able to state, as a result of observations made in 1878, that a second glacier, of equal magnitude, and discharging to the north-westward, had occupied Queen Charlotte Sound. These two great glaciers filled the wide orographic valley which separates the mountain systems of Vancouver Island from those of the coast ranges. They were supplied by tributary glaciers arising in these ranges, but particularly by those of the last named range, and probably received in addition, a great quantity of ice from the confluent glacier-mass of the interior plateau, which was forced seaward through the low gaps in the coast ranges. Evidence was found in the vicinity of Victoria and Nanaimo, to prove that when the Strait of Georgia glacier decreased and shrank back, the land was at a relatively lower level than at present, and that the deposits found in these localities to contain marine shells, were formed at or near the wasting edge of the glacier† Strait of Georgia glacier. Queen Charlotte Sound glacier.

* See particularly, On the Superficial Geology of British Columbia. Quart. Journ. Geol. Soc., Vol. XXXIV. Additional Observations on the Superficial Geology of British Columbia and Adjacent Regions. Ibid. Vol. XXXVII. Notes on the Glaciation of British Columbia. Canadian Naturalist, Vol. IX.

† Quart. Journ. Geol. Soc. Vols. XXXIV., p. 96, XXXVII. p. 297.

Observations on direction of ice-movement.

No reasonable doubt can, I believe, be entertained respecting the existence and general features of the two great glaciers, as above outlined. During the geological examination of the coast here reported on, the direction of glacial striation and grooving was recorded at a great number of points. As, however, the separate enumeration of these could serve no useful purpose, it is proposed merely to note the main directions of ice movement indicated by them. In this connection, it should be observed, that in a region possessing such marked physical features as this, single observations do not possess the same value as those made in a more nearly level country. The glacier-mass, which has buried the great valley to the north-east of Vancouver Island, while flowing out in a general way to the north-west and south-east, from a median point situated in the vicinity of Seymour Narrows, has often swerved locally through many degrees, in consequence of the bold character of the surface over which it passed. Whether such deflections affected the whole thickness of the glaciers, when at their maximum, or whether only the lower parts of the mass conformed in direction to that of the hollows and valleys previously worn out, while the upper moved steadily in a single direction, can scarcely yet be affirmed. From examples seen on a small scale, however, (some of which, in the vicinity of Victoria, have previously been described) the latter supposition would appear the more probable, and by comparing directions obtained near the sea-level, with those to be found on the summits of the higher hills in the same vicinity, this point might be definitely settled.

Local deflections.

General direction.

In general, it is found that the striation and grooving in the various channels and narrow water-ways, shows that the ice has moved through these parallel to their length, the course of the motion being in each case that most nearly conforming to the movement of the mass as a whole. This remark must not, however, be taken as referring merely to hollows now flooded, the same effect having been produced, to a greater or less extent, by all irregularities of the surface. Even in the channels and fiords, only those instances of striation which occur crossing flat points or islands, can be accepted as showing the true course of the ice; as on inclined surfaces, or where bold points or cliffs occur, the direction of striation varies through a number of degrees in the same channel. Vertical surfaces are often well glaciated, and give evidence of great lateral as well as downward pressure. Under-cutting of such surfaces is sometimes seen, and heavy grooving not infrequently runs upward or downward at considerable angles from the horizontal, where channels are markedly widened or constricted.

Glaciated vertical surfaces.

Strait of Georgia glacier.

As stated in a previous paper, the general direction of motion of the

ice which has over-ridden the low south-eastern end of Vancouver Island, near Victoria, as derived from a large number of observations, is S. 11° W. At Nanaimo, heavy glacial grooving was observed running in a south-eastward direction, parallel to the coast and to the main direction of the strait, and glaciation similarly parallel to the shore, was seen on the mainland side of the strait, to the east and north of Texada Island.

At the south end of Texada Island, the glaciation has been nearly parallel to both shores, showing a certain amount of convergence. Across Mitlenatch Island—which may be accepted as a crucial instance, on account of its isolated situation in the centre of the northern part of the strait—the glacial grooving runs about S. 17° E. **Texada Island.**

In the southern part of Discovery Passage, opening from the northern end of the Strait of Georgia, the glaciation is south-eastward, in conformity with the general trend of the passage. On the opposite or east side of the northern end of the Strait, the ice has moved south-westward down Desolation Sound, and in the numerous intervening passages and channels, it has pursued in each case a southward course as nearly as the main direction of the channel would permit. **Discovery Passage.** **Desolation Sound.**

About the mouth of Bute Inlet, which has formed one of the main feeders of the Strait-of-Georgia glacier, the mountain sides were found to be ice-smoothed to a height of 3000 feet or more, and similar evidence has been obtained by myself and Mr. Richardson, in several of the fiords both to the north and south of this place. **Bute Inlet.**

The point from which the glacier-mass has moved in opposite directions toward the Strait of Georgia and Queen Charlotte Sound respectively, has been in Discovery Passage, about midway between the position of Seymour Narrows, and Chatham Point at the north end of the passage. At a place five miles south of Chatham Point, on the west side of the passage, the glaciation was observed to run S. 36° W., almost directly athwart the trend of the passage and towards rather high hills situated not far inland, on Vancouver Island. **Neutral point.**

Beyond Chatham Point, the ice has moved westward and north-westward along Johnstone and Broughton straits, and specially heavy glaciation was noted about the islands and channels near the opening of Knight Inlet to Queen Charlotte Sound. The valleys and channels on the north side of Johnstone Strait, have brought in tributary ice at considerable angles to the general westward direction of flow, while in the eastern part of Broughton Strait, about Pearce Islands and Hanson Island, there is ample evidence of a change in direction to the north-westward, the ice moving out toward the larger hollow now occupied by the east end of Queen Charlotte Sound. **Queen Charlotte Sound glacier.**

Results of heavy ice pressure.

In this vicinity, and elsewhere, where the pressure of the ice has been very heavy, it was observed that projecting bosses on horizontal surfaces (due either to original inequalities of the surface, or to the greater resistance offered by the harder parts to erosion) were often bordered on the side against which the ice impinged, by one or two concentric furrows, which, in some cases, are several inches in width. Somewhat similar effects were seen on vertical surfaces where the ice has been squeezed through narrow rocky passes. A remarkable instance of this kind, sketched near the north-east point of the Pearce Islands, is here illustrated. It appears probable that the grooves shown in the engraving, and others like them, have been formed on the exposed side of bosses, which, when the lateral pressure became less, were ground off flat, leaving only the curved hollows on a plane striated surface. It must, however, be admitted that sculpturing of this kind is somewhat difficult of explanation, where the surfaces affected, as in this instance, are composed of a homogeneous hard rock.

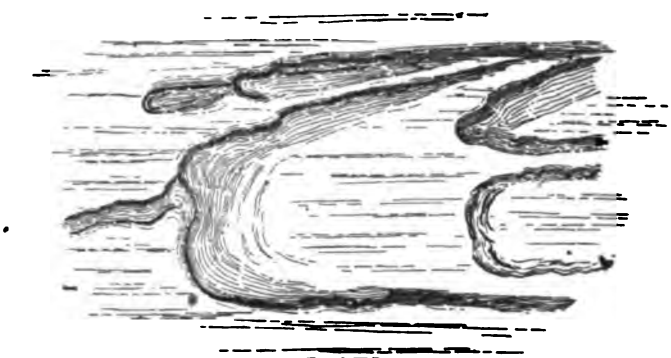

FIG. 3. VERTICAL ROCK-SURFACE, GLACIALLY GROOVED. PEARSE ISLANDS, QUEEN CHARLOTTE SOUND.

Direction of ice-movement, from left to right. Area of rock-surface 12 feet by 24 feet.

Nimpkish Valley.

On Nimpkish Lake and River, the striation shows a northward direction of movement, from the mountainous region of the centre of Vancouver Island toward Queen Charlotte Sound. The Cretaceous rocks bordering the coast from this place north-westward to Beaver Harbour, owing to their soft character, afford little clue to the direction of glaciation, but some facts observed on the upper part of Quatsino Sound, shows it to be not improbable that a portion of the Queen-Charlotte-Sound glacier crossed this low portion of Vancouver Island. About Beaver Harbour, and on the little islands of the Masterman Group, lying off the coast between Beaver Harbour and Hardy Bay,

North-west extremity of Vancouver Island.

very heavy glaciation occurs in bearings varying from N. 49°, W. to N. 62° W. On the north-east side of Queen Charlotte Sound, the glaciation is again nearly parallel to the shore, in a west-north-westward bearing, though local glaciation was seen following the valley of the lagoon which opens from Blunden Harbour, with a southward course, or nearly at right angles to this. On Numas and Foster islands, which lie in the centre of the wide sound, where the direction of the glacier's motion cannot have been affected by local irregularities, the striation and grooving runs N. 89° W.

North-east side of sound.

At the north end of Vancouver Island, a portion of the Queen-Charlotte-Sound glacier has occupied Goletas Channel, and a part of the ice has been forced northward past Galiano Island and between the islands of the Gordon Group. It also appears to have crossed Hope Island in a northward direction by the hollow now occupied by Bull Harbour.

Limit of glaciation westward.

In following the north coast westward, moderately heavy glaciation continues to appear, parallel in direction to the shore, to North-west Nipple, a few miles beyond Cape Commerell. The traces of glaciation are here, however, less marked, and usually confined to the rounding, more or less perfeet, of pre-existing irregularities, repeating the appearances seen at the higher levels near Victoria, and indicating, very probably, the approximate position of the end of the Queen Charlotte Sound glacier in this direction.

With the exception of some rather dubious traces which appeared to show a seaward movement of ice in San Josef Bay, no signs of glacial action were noted about the north-western extremity of Vancouver Island, or on its exposed west coast. Such traces may, very probably, have been obliterated along these shores by the action of the waves, the whole of this coast being, as previously mentioned, much exposed, and showing abundant evidence of great sea erosion still actively in progress. It is probable, however, that the glaciation has here not been very heavy, as otherwise some remnants of it might have been observed.

West Coast.

The small number and limited areas of terrace deposits along the entire coast of British Columbia has been referred to in the papers previously quoted. The region embraced by the present report offers no exception in this respect to the general rule, and no instances were observed of terraces at a greater height above the present sea-level than about 200 feet. Some of the lower tracts of land—particularly those characterized by the Cretaceous sandstones—are covered to a considerable depth by detrital deposits, and the same remark applies to a number of sheltered valleys in the higher regions. Boulder-clay was noted in some such localities, but, in general, only the more superficial stratified sands and gravels were found to be exposed.

Superficial deposits not abundant.

Notable exceptions.

To this general statement, the most notable exceptions are found in the low islands and points of low land which fringe the northern extremity of the Strait of Georgia, and in Malcolm and Cormorant Islands, which occupy a relatively similar position at the eastern end of Queen Charlotte Sound. It has previously been suggested* that the islands and adjacent low tracts of land composed of detrital materials, and forming the projecting portions of a comparatively shoal bank at the north-east of the Strait of Georgia, may be assumed to represent the position of a moraine, formed during a period of arrest in the decrease of the great glacier, when its length had been reduced by at least one hundred miles. A closer examination has thrown additional light on this point.

Two boulder-clays.

At one place, on the Vancouver shore, about four miles north of Cape Lazo, a section in a bank about forty feet high, shows at the base a hard, bluish boulder-clay, with some traces of stratification, overlain by ten to fifteen feet of hard, well-bedded, fine sands, which in turn are followed by a hard, yellowish, rather sandy boulder-clay, the whole being capped by a few feet of yellow sand and gravel. In Cape Lazo, hard, bedded, silty or sandy deposits are overlain by boulder-clay. A similar succession was observed in a small patch of drift in a cove in Discovery Passage, a short distance south of Seymour Narrows, on the east side, and again on a larger scale in Cape Mudge, where the underlying silty deposit joins the boulder-clay above, along an irregularly undulating line. Mary, Hernando, Savary and Harwood islands, are chiefly composed of hard, well bedded, horizontally stratified sands and silts of pale colours, but in the cliffs on the south side of Savary Island, these are clearly seen to be overlain by boulder-clay, which rests upon them in irregular

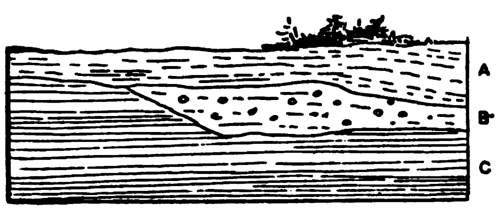

FIG. 4. DIAGRAMATIC SECTION OF DRIFT DEPOSITS. SAVARY ISLAND.

A. Stratified sands and gravels.
B. Boulder-clay.
C. Hard, well bedded silts and sands.

hollows, and is in turn overlain by rather incoherent yellowish, irregularly bedded sands and gravels, as represented diagramatically in

* Quart. Journ. Geol. Soc. Vol. XXXVII, p. 278.

the annexed figure. At the west end of this island, pretty good proof was found that the stratified silts rest directly on glaciated rock-surfaces.

With the exception of the first-noted section, no direct evidence of the superposition of the stratified silts on a lower boulder-clay was discovered, but the large and very numerous boulders which are strewn over the wide tidal flats and beaches of the islands last enumerated, may reasonably be assumed to have been derived from such an underlying boulder-clay, as the deposits which have been worn back in the cliffs, seem incapable of having afforded them.

It would thus appear, that there are in the vicinity of the northern part of the Strait of Georgia, two distinct boulder-clays, of which the lower is in all probability equivalent to that which immediately overlies the glaciated rock-surfaces in the southern part of the strait and near Victoria. Water action, as shown by bedding, is more or less apparent throughout the whole of the deposits, but in the important intercalation of bedded silts—essentially a loess deposit—we find evidence of a period during which the great glacier had shrunk back so far as not to have reached to the open water of the strait. This period must have been of considerable length, and during it, the turbid waters derived from glaciers in the narrower inlets, were quietly depositing their fine, suspended material. The sea must have been at this time, at an elevation of from 100 to 200 feet greater than at present. At a later date, the glacier either again pushed forward to a limited distance over the bedded silts, leaving the upper boulder-clay along its front during its final retreat, or subsidence being continued, the water became sufficiently deep to allow detached floating ice from the smaller glaciers to transport and lay down this upper boulder-clay. Mode of formation of deposits.

Notwithstanding difficulties which occur in connection with the first hypothesis, the now compacted character of the silts, together with the sharpness of their plane of junction with the overlying boulder-clay, appear to be in its favour, and if correct, this explanation will accord well with the fact of the occurrence of a second and less intense period of glaciation. Of this good proof has now been found both in the interior of British Columbia and on the Great Plains to the east of the mountains. Two maxima of glaciation.

The stratified silts and sands of Cormorant and Malcolm islands, are identical with those above described, but neither the upper nor the lower boulder-clay was clearly seen in association with them here. The islands and coasts within the line of these important remnants of drift deposits of the upper ends of the Strait of Georgia and Queen Charlotte Sound, are almost absolutely destitute of superficial deposits, and may be supposed to have been swept bare during the second advance of the ice. Cormorant and Malcolm Islands.

Fossils.

The only locality within the region here specially described in which the deposits referable to the glacial period were found to contain fossils is that already referred to on p. 55 B, on the shore of the Embley Lagoon, on the north-east side of Queen Charlotte Sound. Hard sandy clays, exposed on the beach at this place, afforded a few casts of molluscs, from which the whole of the calcareous matter had been removed. Among these Mr. Whiteaves recognizes *Saxicava rugosa* var. *arctica*, and *Leda minuta* var. (?)

Changes in level.

Having on a former occasion discussed the evidences of changes in level of the coast of British Columbia as a whole,* this question need not here be entered into. It may be stated, however, that the rather frequent occurrence in this district of a low terrace, or of beach deposits, at about ten or fifteen feet above the present high-tide mark, indicates a comparatively recent elevation to that extent, further evidence of which may be afforded by the very fresh and unworn character of the glaciated rock-surfaces now exposed to the action of the sea along the shores.

Note on Distribution of Trees.

Value of forests.

The great extent and value of the timber of the coast of British Columbia and Vancouver Island is now being more fully discovered. Along the actual shore-lines and on the rocky and mountainous tracts, the timber is usually of a somewhat inferior quality, but in the more level inland regions, and in valleys which are sheltered from the violence of the winds, there are everywhere great quantities of fine trees, capable of supplying an almost unlimited amount of timber when the necessary facilities are provided for bringing out the logs to the shore. The greatest present need is the protection of the forests against fires. The islands and coasts of the Strait of Georgia constitute a region to a considerable extent climatically diverse from that of Queen Charlotte Sound, and from the west coast of Vancouver Island, being less humid than either of these, and a number of plants are found in this special region which do not occur elsewhere in the province. Of trees, the arbutus (*Arbutus Menziesii*) and the oak (*Quercus Garryana*) are altogether confined to it within the limits of British Columbia. The oak is last seen to the north-westward in prairie lands along the Comox River. The arbutus, which never in this region exists far from the shore, was observed, to the northward, in a shrubby form a few miles northward of Seymour Narrows, or to Elk Bay in Discovery Passage.

Restricted limits of some plants.

* Note on some of the More Recent Changes in Level of the Coast of British Columbia and Adjacent Regions. Canadian Naturalist, Vol. VIII., p. 241. See also Report of Progress Geological Survey of Canada, 1878-79, p. 94 B, and papers previously quoted.

To the north-eastward it extends to the Redonda Islands, in the mouth of Toba Inlet.

Douglas fir and yellow cypress.

The Douglas fir (*Pseudotsuga Douglasii*), the most important timber tree of the region, is abundant on the inner shores of Vancouver Island and on the adjacent mainland, but does not occur on the northern extremity of the island or on the west coast, though it reappears in considerable abundance on the upper part of Quatsino Sound. The yellow cypress (*Thuya excelsa* = *Chamæcyparis Nutkaensis*), found at a considerable elevation on the hills near Burrard Inlet and elsewhere near the coast of the southern part of the Strait of Georgia, was observed near the water-level on the Nimpkish Lake, but comes down first to the sea-shore in the vicinity of Blunden Harbour, on Queen Charlotte Sound. In the northern part of Vancouver Island, it is most abundant on the higher hills and plateaus, to which the Indians are in the habit of resorting when they require a supply of the bark. The white pine (*Pinus monticola*) was observed in a number of places both in the Strait of Georgia and Queen Charlotte Sound, but never in large groves.

Other trees.

The following species were noted in greater or less abundance over the entire area covered by this report:—Western hemlock (*Tsuga Mertensiana*), western cedar (*Thuja gigantea*), Menzie's spruce (*Picea Sitchensis*), western scrub pine (*Pinus contorta*), yew (*Taxus brevifolia*), alder (*Alnus rubra*).

The juniper (*Juniperus Virginiana*) was found assuming an arboreal form only on the shores of the Strait of Georgia.

APPENDIX I.

NOTES ON SOME MESOZOIC FOSSILS FROM VARIOUS LOCALITIES ON THE COAST OF BRITISH COLUMBIA, FOR THE MOST PART COLLECTED BY DR. G. M. DAWSON IN THE SUMMER OF 1885.

BY J. F. WHITEAVES.

(1.) TRIASSIC SPECIES.

MONOTIS SUBCIRCULARIS, Gabb.

Monotis subcircularis, Gabb.—1864. Palæont. Californ., Vol. 1, p. 31, pl. 6, figs. 29, 29a.

A few miles above Fossil Point, on the Peace River, lat. 56° 10′ long. 122° 10′, A. R. C. Selwyn, 1875. Fossil Ridge, Upper Pine River, lat. 55° 30′ long 122°, J. Hunter, 1877. South side of Houston Stewart Channel, Queen Charlotte Islands, nearly opposite Rose Harbour; Section Cove, north end of Barnaby Island, Q.C.I.; and south side of Skidegate Channel, Q.C.I., a mile and a half west of Log Point; G. M. Dawson, 1878.

HALOBIA (DAONELLA) LOMMELI, Wissmann.

Halobia Lommeli, Wissmann.—1841. Beitr. Petref., IV. Heft, 22, tab. 6, fig. 11.
" " Horness.—1855. Densk. Kais. Akad. Wissench. IX, 52, taf. 2, fig. 17.
" " Zittel.—Fossile Moll. und Echinodermen aus Neu-Seeland, 27, taf. 6, figs. 1*a*, *b*, *c*.
" " Stoliczka.—1866. Mem. Geol. Surv. Ind., V, 44.
Avicula pectiniformis, Catullo.—1847. Prodr. Pal. Alpi. Ven., 73, pl. 1, figs. 1, 2, 3.
Posidonomya Lommeli, d'Orbigny.—1849. Prodr. du Paleont. Stratigr. Univ., I, 201.
? *Halobia dubia*, Gabb.—1864. Palæont. Californ., Vol. I, p. 30, pl. 5, figs. 28*a*, *b*.
Daonella dubia, Mojsisovics.—1874. Ueber der Triasch. Pelecyp. Gatt. Daonella und Halobia, p. 22.
Halobia (Daonella) Lommeli, Meek.—1877. U. S. Geol. Expl. 40th Par., Vol. IV, p. 100, pl. 10, fig. 5.

South side of Houston Stewart Channel, Q.C.I., nearly opposite Rose Harbour; and Section Cove, north end of Barnaby Island, Q.C.I., G. M. Dawson, 1878. Bay five miles west of Cape Commerel, north end of Vancouver Island, G. M. Dawson, 1885.

AULACOCERAS CARLOTTENSE. (N. Sp.)*

Guard elongated, in the more perfect though smaller of the only two specimens collected, which may therefore be regarded as the type of the species, narrowly conical and increasing very slowly in thickness from the acutely pointed posterior end, whose apex is slightly excentric; in the larger but less perfect example comparatively thick, somewhat fusiform and bluntly pointed posteriorly, with the apex distinctly excentric. Alveolus and phragmocone unknown. Outer surface marked by close-set, rounded, longitudinal ribs, which are separated from each other by narrow but deep linear furrows.

In 1878 six badly preserved specimens of the guards of one or more species of Belemnites were collected by Dr. G. M. Dawson at Houston Stewart Channel, in the Queen Charlotte Islands. Of these, the two described above are both longitudinally ribbed on the outside, and apparently belong to the genus *Aulacoceras* of Hauer. The smaller of the two is a natural longitudinal section of the guard, about two inches in length and not quite half an inch broad at the thickest end, while the larger, which is only a badly-preserved natural mould or impression of one side of a large specimen of the guard with part of the test preserved at the posterior end, but which shows clearly one of the lateral grooves that are said to be characteristic of the genus, is nearly five inches in length and fully an inch and a half broad in the thickest part. Of the other four specimens two are mere fragments which cannot be determined either generically or specifically, one being a very slender guard about two inches and a half long and not quite a quarter of an inch broad at the thicker end, whose surface markings are not preserved, while the other is a piece of the posterior or pointed end of the guard of a small individual, about an inch and a quarter long and a quarter of an inch broad at the thicker end, whose surface appears to be perfectly smooth.

* Illustrations of all the new species proposed in this paper are in preparation. These will be issued in one of the parts of the "Contributions to Canadian Palæontology," as soon as practicable.

ARCESTES GABBI, Meek.

Arcestes Ausseanus, Gabb.—1864. Palæont. Californ., Vol. I, p. 25, pl. 3, figs. 26 and 17 (not of Hauer, teste Meek).
Arcestes Gabbi, Meek. —1877. U. S. Geol. Expl. 40th Parallel, Vol. IV, pt. I, p. 121, pl. 10, figs. 6, 6*a* and 6*b*.

Bay five miles and a half west of Cape Commerell, north end of Vancouver Island, G. M. Dawson, 1885; one tolerably perfect specimen and a few fragments of others.

CELTITES (?) VANCOUVERENSIS. (N. Sp.)

Shell discoidal, compressed, whorls four to five, slender, gently convex at the sides, increasing very slowly in size and very slightly involute, so that the whole of the sides of the inner ones are exposed to view: umbilicus wide and extremely shallow: outer volution distinctly keeled at the periphery: exterior of the whole test strongly ribbed, the ribs simple, transverse, generally straight, broadening outwards and interrupted on the keeled periphery of the outer volution. Siphuncle and septum unknown.

North entrance point of Houston Stewart Channel, Queen Charlotte Islands, at east end of channel; Crescent Inlet, Moresby Island, Q.C.I., and north shore of Kun-ga Island, Q.C.I.; also Browning Creek, Forward Inlet, Quatsino Sound, Vancouver Island, and Forward Inlet, near Observatory Rock; G. M. Dawson, 1878.

Robson Island, Forward Inlet, and east side of Winter Harbour, Forward Inlet, a mile and a half north of Log Point; Alexander Harbour, Galiano Island, north end of Vancouver Island, and Hernandez Island, Strait of Georgia; G. M. Dawson, 1885.

With the exception of a few crushed fragments, all the specimens from these localities are mere natural moulds or impressions in shale of one side only of each shell, in which not a vestige of any part of the sutural line can be detected. Gutta-percha casts made from the most perfect of these moulds are very similar in shape and sculpture to the Nevada fossil which Meek has identified with the *Clydonites lævidorsatus* of Hauer, but in the former the periphery is distinctly keeled, while in the latter the same part of the shell is described as being "more or less narrowly rounded." In the specimens collected by Dr. Dawson, so little of the external keel is preserved, and its characters are so imperfectly exhibited, that, although it is quite clear that it is neither crenate nor serrated, it is quite impossible to tell whether it was originally simple or divided by a longitudinal median groove as in *Arpadites*.

Some of the best specimens were sent to Professor Hyatt, who makes the following remarks upon the species in a recent letter to the present writer: "It is remarkably *Arietes*-like in aspect, and if it were from the Lower Lias the exact genus could be pointed out without difficulty as *Arnioceras*. If a Triassic species, as you suggest, I should think it might belong either to *Arpadites*, *Celtites* or *Balatonites*. The ribs, straight, undivided, and the aspect of the umbilicus are very like either of the last two, but which it is most like I find myself unable to decide. *Arpadites* is more apt to have curved ribs, tuberculated near the umbilicus, and wider in the abdomino-dorsal diameter. Having no sutures, we are of course necessarily groping in the dark, since almost any of the three Ceratitic genera mentioned above might have discoidal radical forms like these specimens."

The species is so characteristic of a definite horizon in the Triassic rocks at several localities in the Queen Charlotte and Vancouver groups of islands that, although its generic position is so uncertain that it is doubtful even whether it should be referred to the *Tropitidæ* or *Ceratitidæ*, it nevertheless seems desirable, as a matter of convenience, to propose for it a local and purely provisional name.

(2.) CRETACEOUS SPECIES.

AUCELLA PIOCHII, Gabb.

Inoceramus Piochii, Gabb.—1864. Pal. Californ., Vol. I, p. 187, pl. 25, fig. 173 (exclus. fig. 174).
Aucella Piochii, Gabb. —1869. Pal. Californ., Vol. II., p. 194, pl. 131, figs. 92, *a-c*.

Tatlayoco Lake, B.C., G. M. Dawson, 1875. Banks of the Upper Skagit River, B.C., G. M. Dawson, 1877, and Browning Creek, Forward Inlet, Quatsino Sound, north-west coast of Vancouver Island, G. M. D., 1878.

Long Island, Harrison Lake, B.C., also west shore and peninsula on the south-east shore of the same lake, and Chilliwack River, near Tamiahai Creek, B.C., A. Bowman, 1882.

Browning Creek, Forward Inlet and west side of Winter Harbour in Forward Inlet, also Raft Cove on the west coast of Vancouver Island, north of Quatsino Sound, G. M. Dawson, 1885.

West of Fraser River, B.C., a little to the north of sources of Bridge River, B.C., from a mountain six or seven thousand feet high above sea level, Mr. Soues (per Mr. T. Elwyn), 1886. South Fork of Quesnel River, near the foot of Quesnel Lake, A. Bowman, 1886.

In an article "On the Lower Cretaceous Rocks of British Columbia,"* the writer has already expressed the opinion "that the *Aucella Piochii* of Gabb cannot be distinguished from the *A. Mosquensis* of Von Buch, even as a local variety," and the only reason why the former name is provisionally retained in this and in previous papers is to show that the specimens from British Columbia are precisely similar to those which are so characteristic of a well-marked horizon in the Shasta Group of California.

YOLDIA ARATA, Whiteaves.

Yoldia arata, Whiteaves.—1884. Geol. and Nat. Hist. Surv. Can., Mesoz. Foss., Vol. I., p. 233, pl. 31, figs. 4 and 4*a*.

East side of Winter Harbour, Forward Inlet, G. M. Dawson, 1885; a few casts of the interior of the shell of a small *Yoldia* which are somewhat doubtfully referred to this species.

ASTARTE PACKARDI.

Astarte Packardi, Whiteaves (as of White).—1884. Geol. and Nat. Hist. Surv. Can., Mesoz. Foss., Vol. I, p. 229, pl. 30, figs. 6, 6*a* and 6*b*; but possibly not *A. Packardi*, White, 1880, U. S. Geol. Surv., Contr. to Pal., Nos. 2-8, p. 149, pl. 37, figs. 6*a* and *b*.

Same locality, collector and date as the preceding. A few imperfect and badly preserved valves of an *Astarte* which can scarcely be distinguished from a species from the "Lower Shales" of the Queen Charlotte Islands, which the writer has identified with the *A. Packardi* of White, although in the former the surface seems to have been coarsely and irregularly striated or finely plicated, while in the latter it is regularly and distinctly ribbed.

It is only proper to add, also, that Dr. White regards the Queen Charlotte Island species as distinct from his *A. Packardi*.

OPIS VANCOUVERENSIS, Whiteaves.

Opis Vancouverensis, Whiteaves.—1879. Geol. and Nat. Hist. Surv. Can., Mesoz. Foss., Vol. I, p. 158, pl. 18, figs. 4 and 4*a*.

West end of Lasqueti Island (in the Strait of Georgia) near False Bay; a cast of the interior of the right valve of a shell which almost certainly belongs to this genus, and most probably to this species.

* Trans. Royal Soc. Can., Vol. I., Section IV., pp. 81-86.

Pleuromya lævigata, Whiteaves.

Pleuromya lævigata, Whiteaves.—1884. Geol. and Nat. Hist. Surv. Can., Mesoz. Foss., Vol. I, p. 224, pl. 30, figs. 1, 1*a*, 1*b* and 1*c*.

Nookneamish River, north-west end of Vancouver Island, G. M. Dawson, 1885, six badly preserved but nearly perfect and eight imperfect casts of the interior of the shell. These specimens are very variable in shape, no two being alike.

Placenticeras occidentale. (N. Sp.)

Perhaps a variety of *Ammonites bicurvatus*, Michelin, which Zittel (Handbuch der Palæontologie, vol. 2, p. 452) says is a *Placenticeras*.

Cfr. *Ammonites bicurvatus*, Mich., d'Orbigny.—1840-42. Pal. Franc., Terr. Cret., tome I, p. 286, pl. 84, figs. 3 and 4, but not (teste Pictet) figs. 1 and 2.

Shell strongly compressed at the sides, periphery rather sharply angulated but not distinctly keeled: outer whorl very closely embracing, umbilicus rather narrow, a little less than one-fourth of the greatest diameter: aperture narrowly sagittate, its base deeply emarginate by the encroachment of the preceding volution.

Surface of the sides of the outer whorl marked by broad and rather distant, radiating, bifurcating and doubly flexuous raised plications, which commence at the umbilical margin, curve at first gently forwards, then as gently backwards, and are finally bent very abruptly forwards next to the periphery, upon which they form narrow, elongated and acute tongue-like processes. In addition to these plications the surface is marked by fine, simple and comparatively close-set, radiating raised lines, which are also doubly flexuous on each side. These raised lines are most strongly marked on the outer half of the sides, and are as well defined on the summits of the plications as in the smaller spaces between them. Septation unknown.

K-uk River, coast of British Columbia, G. M. Dawson, 1885; one tolerably well preserved but somewhat imperfect cast of the interior of the shell, whose greatest diameter is a little less than five inches.

The species seems to differ from *P. bicurvatus*, not only in its much greater size, but also in the presence of numerous, fine-set and doubly flexuous raised lines, in addition to the radiating plications or rib-like folds which are common to both.

Scaphites Quatsinoensis.

Olcostephanus Quatsinoensis, Whiteaves.—1882. Trans. Roy. Soc. Can., Vol. I., Section IV., p. 82, woodcut fig. 1.

East side of Winter Harbour, Forward Inlet, Quatsino Sound, V.I., G. M. Dawson, 1885, two well preserved and nearly perfect but not quite adult specimens, and a few fragments.

These show clearly that the species is not an *Olcostephanus* of the type of *O. bidichotomus*, as was at first supposed, but a finely-ribbed small Scaphite very nearly related to the *Scaphites æqualis* of Sowerby. Its ribs too are not invariably bidichotomous, for in some of the specimens collected in 1885 they are trifurcated, while in others, in closely contiguous portions of the same specimen, they are bidichotomous, trifurcated, or simple with shorter ones intercalated between, though they are apparently never tuberculated nor nodose.

The type of *O. Quatsinoensis* is a well preserved but very imperfect and immature specimen, collected by Dr. Dawson in 1878 at Browning Creek, Forward Inlet, where it is associated with an abundance of *Aucella Piochii*. The occurrence of a small Scaphite associated with these *Aucellæ* suggests the idea that the rocks which contain so many of the latter may be much newer geologically than has as yet been supposed.

In addition to the foregoing, a few Cretaceous fossils whose specific relations are at present obscure, were collected by Dr. Dawson in 1885 at the following localities. From the west end of Lasqueti Island, near False Bay, a single specimen of a finely ribbed *Terebratella*, apparently undescribed but too imperfectly preserved to show its characters satisfactorily; two small valves of an *Ostræa*, and a fragment of a valve of a *Pecten*. From Nookneamish River, coast of British Columbia, numerous casts of the interior of the shell of a small *Trigonia*; and from the east side of Winter Harbour, Forward Inlet, casts of an undetermined species each of the genera *Dentalium*, *Cinulia*, *Protocardium* and *Arca*.

APPENDIX II.

LIST OF PLANTS OBTAINED

BY DR. G. M. DAWSON

ON

VANCOUVER ISLAND AND ADJACENT COASTS, IN 1885.

BY PROF. J. MACOUN.

NOTE.—The shores of the Strait of Georgia constitute a distinct region climatically from that of Queen Charlotte Sound and the northern and western parts of Vancouver Island, being characterized by a relatively less copious rainfall and greater summer heat. The flowering plants and ferns of the two districts are therefore separately enumerated. The *Mosses, Liverworts* and *Lichens* are, however, given in a single list. Most of the species enumerated from Sooke were collected by Mr. James Fletcher.

COASTS AND ISLANDS ADJACENT TO THE STRAIT OF GEORGIA.

Arabis perfoliata, (Lam.) Drew Harbor.
Lepidium intermedium, (Gray.) Drew Harbor.
Arenaria peploides, (Lam.) var. *oblongifolia*, (Watson.) Between Cape Lazo and Shelter Point.
Sagina occidentalis, (Watson.) Malaspina Inlet.
Silene antirrhina, (L.) Drew Harbor.
Geranium pusillum, (L.) Drew Harbor.
Trifolium microcephalum, (Pursh.) Drew Harbor.
Vicia gigantea, (Hook.) Sooke.
Rosa Nutkana, (Presl,) Hernando Island.
Heuchera micrantha, (Dougl.) North end of Texada Island.
Tiarella trifoliata, (Hook.) Comox.
Godetia amœna, (Lilja.) Sooke.
Opuntia fragilis, (Haw.) Hernando Island.

Daucus pusillus, (Mx.) Drew Harbor and Mary Harbor.
Peucedanum leiocarpum, (Nutt.) Drew Harbor.
Archangelica Gmelini, (DC.) Sooke.
Osmorrhiza nuda, (Torr.) Sooke.
Lonicera hispidula, (Dougl.) Sooke.
Galium triflorum, (Mx.) Sooke.
Galium aparine, (L.) Sooke.
Grindelia integrifolia, (DC.) A glabrate form. North end of Texada Island.
Gnaphalium purpureum, (L.) Sooke.
Adenocaulon bicolor, (Hook.) North end of Texada Island.
Balsamorrhiza deltoidea, Nutt. Drew Harbor.
Franseria bipinnatifida, (Nutt.) Between Cape Lazo and Shelter Point.
Madia dissitiflora, (T. and G.) North end of Texada Island.
Eriophyllum cæspitosum, (Dougl.) Between Cape Lazo and Shelter Point.
Cnicus edulis, (Gray) North Point of Texada Island.
Senecio aureus, (L.) var. *Balsamitæ*, (T. & G.) North Point of Texada Island.
Hieracium albiflorum, (Hook.) North end of Texada Island.
Campanula Scouleri, (Hook.) Sooke.
Specularia perfoliata, (A. DC.) Drew Harbor.
Vaccinium ovatum, (Pursh.) North end of Texada Island.
Arctostaphylus Uva-ursi, (Spreng.) Sooke.
Trientalis Europæa, (L.) var. *latifolia* (Torr.) Comox.
Amsinckia lycopsoides, (Lehm.) Mary Island.
Convolvulus Soldanella, (L.) Savary Island.
Cuscuta salina, (Engelm.) Hernando Island.
Plantago maritima, (L.) Hernando Island.
Castilleia miniata, (Dougl.) (Leaves three-cleft, uncommon.) Sooke.
Micromeria Douglasii, (Benth.) North end of Texada Island.
Atriplex patula, (L.) var. *littoralis*, (Gray.) Drew Harbor.
Salicornia ambigua, (Mx.) Drew Harbor.
Brunella vulgaris, (L.) North end of Texada Island.
Quercus Garryana, (Dougl.) Comox.
Juniperus Virginiana, (L.) Lasqueti Island.
Tsuga Mertensiana, (Carr.) Sooke.
Pinus monticola, (Dougl.) North end of Texada Island and Sooke.
Pinus contorta, (Dougl.) Sooke.
Pseudotsuga Douglasii, (Carr.) Sooke.
Corallorhiza striata, (Lindl.) Sooke.
Allium acuminatum, (Dougl.) Mary Island.
Zygadenus venenosus, (Watson) North end of Texada Island.

Agrostis exarata, (Trin.) N. end of Texada Island and Blunden Harbor.
Agrostis vulgaris, (With.) Drew Harbor.
Trisetum canescens, (Buckley.) Sooke.
Danthonia Californica, (Bolander.) North end of Texada Island.
Poa Bolanderi, (Thurber.) Sooke.
Glyceria maritima, (Wahl.) North end of Texada Island.
Festuca ovina, (L.) Sooke.
Festuca ovina, (L.) var. Malaspina Inlet, North end of Texada Island.
Festuca microstachya, (Nutt.) Sooke.
Deschampsia elongata, (Munro.) Sooke.
Bromus ciliatus, (L.) Sooke.
Triticum divergens, (Nees.) North end of Texada Island.
Hordeum pusillum, (Nutt.) North end of Texada Island.
Elymus arenarius, (L.) North end of Texada Island.

Northern part of Vancouver Island and Coasts of Queen Charlotte Sound and vicinity.

Stellaria uliginosa, (Murr.) Blenkinsop Bay.
Stellaria borealis, (Bigel.) Blenkinsop Bay.
Hypericum Scouleri, (Hook.) Nimpkish Lake.
Neillia opulifolia, (Benth & Hook.) Nimpkish Lake.
Spiræa discolor, (Pursh) var. *ariæfolia*, (Wat.) Nimpkish Lake.
Solidago elongata, (Nutt.) Nimpkish Lake.
Aster foliaceus, (Lindl.) Nimpkish Lake.
Menziesia ferruginea, (Smith) Nimpkish Lake.
Myrica Gale, (L.) Nimpkish Lake.
Chamæcyparis Nutkænsis, (Spach.) Nimpkish Lake.
Thuya excelsa, (Bong.)
Juncus Balticus, (Deth.) Blenkinsop Bay.
Juncus alpinus, (Vill.) var. *insignis*, (Fries) Nimpkish Lake.
Juncus Mertensianus, (Meyer) Nimpkish Lake.
Juncus falcatus, (Meyer) Nimpkish Lake.
Carex Sitchensis, (Prescott) Blenkinsop Bay.
Carex lenticularis, (Mx.) Nimpkish Lake.
Deyeuxia crassiglumis, (Vasey) Nimpkish Lake.
Deschampsia cæspitosa, (Beauv.) Knox Bay.
Glyceria distans, (Wahl.) Blunden Harbor.
Polypodium Scouleri, (Hook. & Grev.) Cape Scott, north-west point of Vancouver Island.
Lomaria Spicant, (Desv.) Alert Bay.
Asplenium Trichomanes, (L.) Strait of Georgia.
Aspidium spinulosum, (Swz.) var. *dilatatum*, (Hornm.) Alert Bay.

Vancouver Island and Adjacent Coasts.

Musci.

Sphagnum rigidum, (L.) Cape Scott.
Dicranoweisia cirrhata, (Lindb.) Knox Bay.
Dicranum scoparium, (Hedw.) Texada Island and other points.
Dicranum majus, (Turner) Knox Bay.
Ceratodon purpureus, (Brid.) var. *xanthopus*, (Sulliv.) Pearse Island.
Barbula Mulleri, (Bruch and Schimp.) Drew Harbor.
Grimmia apocarpa, (Bruch and Schimp.) Texada Island.
Racomitrium heterostichum, (Brid.) Pearse Island.
Racomitrium varium, (James & Lesq.) Blenkinsop Bay.
Racomitrium lanuginosum, (Brid.) Malaspina Inlet.
Ulota phyllantha, (Brid.) Vancouver Island.
Ulota Barclayi, (Mitt.) Malaspina Inlet.
Mnium spinulosum, (Bruch & Schimp.) Forward Inlet, Malaspina Inlet.
Mnium punctatum, (Hedw.) Johnston Strait, Harbledown Island, and Comox.
Mnium Menziesii, (Muell.) Malaspina Inlet.
Mnium affine, (Bland) Malaspina Inlet.
Aulacomnion androgynum, (Schw.) Malaspina Inlet.
Pogonatum alpinum, (Roehl.) Comox.
Polytrichum piliferum, (Schreb.) Texada Island.
Neckera Douglasii, (Hook.) Johnston Strait.
Antitrichia curtipendula, (Brid.) Harbledown Island.
Hypnum (Heterocladium) heteropterum, (Bruch) Comox.
Hypnum (Claopodium) ramulosum, (Hampe.) Texada Island.
Hypnum (Eurhynchium) Stokesii, (Turn.) Alert Bay.
Hypnum (Eurhynchium) Oreganum, (Sulliv.) Texada Island.
Hypnum (Isothecium) myosuroides, (Mitt.) Texada Island, Johnston Strait, Redonda Islands and Forward Inlet.
Hypnum (Brachythecium) asperrimum, (Mitt.) Comox.
Hypnum (Isothecium) stoloniferum, (Hook.) Texada Island, Harbledown Island.
Hypnum (Thamnium) neckeroides (Hook.) Comox.
Hypnum (Hypnum) Sequoieti, (Muell.) Malaspina Inlet, Texada Island and Thurlow Islands.
Hypnum (Hypnum) subimponens, (Lesq.) Comox.
Hypnum (Pleurozium) splendens, (Hedw.) Johnston Strait, Alert Bay.
Hypnum (Hylocomnium) loreum, (Linn.) Forward Inlet, Johnston Strait.
Hypnum (Plagiothecium) undulatum, (L.) Harbledown Islands and vicinity.

Hepaticeæ.

Anthoceros stomatifer, (Aust.) Redonda Islands.
Metzgeria conjugata, (Aust.) Blenkinsop Bay.
Frullania Grayana, var. *Californica*, (Aust.) Redonda Islands.
Frullania Bolanderi, (Aust.) Hanson Island and Alert Bay.
Lepidozia Californica, (Aust.) Alert Bay.
Radula Hallii, (Aust.) Alert Bay.
Jungermannia Schraderi, (Mart.) Alert Bay.
Jungermannia, Sp. Forward Inlet.
Jungermannia, Sp. Harbledown Islands.
Scapania nemorosa, (Nees.) Hanson Island.
Scapania Bolanderi, (Aust.) Alert Bay.

Lichenes.

Ramalina reticulata, (Noehd.) Common in woods.
Ramalina calicaris, var. *farinacea*, (Fr.) Alert Bay.
Ramalina calicaris, Var. On trees, Thurlow Island. Only one small specimen.
Cetaria sæpincola, Ach.) var. (b) *chlorophylla*, (Wahl.) Thurlow Islands and Pearse Islands.
Cetaria lacunosa, (Ach.) Hernando and Hanson islands.
Cetaria lacunosa, (Ach.) var. (b) *stenophylla*, (Tuck.) Hanson Island.
Cetaria glauca, (Ach.) Hernando Island and Pearse Island.
Alectoria ochroleuca, var. *sarmentosa*, (Nyl.) Pearse Island and Thurlow Islands.
Parmelia physodes, (Ach.) Hanson Island.
Parmelia physodes, var. *enteromorpha*, (Tuck.) Thurlow Island, Redonda Island, Alert Bay and Harbledown Island.
Parmelia saxatilis, (Fries) Redonda Island, Harbledown Island and Thurlow Island.
Umbilicaria angulata, (Tuckerm.) Harbledown Islands.
Sticta pulmonaria, (Ach.) Alert Bay, Forward Inlet and Johnston Strait.
Sticta Oregana, (Tucker) Comox and Alert Bay.
Sticta scorbiculata, (Ach.) Comox, Pearse Islands and Redonda Island.
Sticta, Sp. Redonda Island.
Nephroma Lusitanicum, (Schœr.) Comox and Thurlow Island.
Peltigera aphthosa, (Hoffm.) Harbledown Island and Comox.
Peltigera polydactyla, (Hoffm.)
Peltigera scutata, (Leight) Harbledown Island.
Peltigera canina, (Hoffm.) Pearse Island and Comox.

Leptogium palmatum, (Mont.) Forward Inlet.
Placodium elegans, (C.) Harbledown Island.
Placodium aurantiacum, (N. & H.) Blenkinsop Bay.
Lecanora subfusca, (Ach.) Hanson Island, Blenkinsop Bay and Pearse Island.
Lecanora pallescens, (Schœr.) Comox and Alert Bay.
Lecanora, (Sp.) Thurlow Islands.
Pertusaria ambigens, (Tuck.) Pearse Island.
Stereocaulon tomentosum, (Fr.) Thurlow Islands and Hanson Island.
Cladonia pyxidata, (Fr.) Thurlow Islands.
Cladonia fimbriata, var. *tubæformis*, (Fr.) Alert Bay, Thurlow Island, and Redonda Islands.
Cladonia gracilis, var. *verticillata*, (Fr.) Forward Inlet and Knox Bay,
Cladonia gracilis, var. *hybrida*, (Fr.) Redonda Islands.
Cladonia squamosa, (Hoffm.) Redonda Islands, Knox Bay, and Thurlow Island.
Cladonia furcata, var. *crispata*, (Fl.) Alert Bay and Hanson Island.
Cladonia furcata, var. *racemosa*, (Fl.) Thurlow Island and Hanson Island.
Cladonia furcata, var. *subulata*, (Fl.) Hansom Island and Comox.
Cladonia furcata, (Fr.) Harbledown Island.
Cladonia rangiferina, var. *alpestris*, (Hoffm.) Hanson Island and Knox Bay.
Cladonia cornucopioides, (Fr.) Hanson Island and Johnston Strait.
Cladonia bellidiflora, (Ach.) Thurlow, Hanson, and Pearse islands and Johnston Strait.
Boemyces æruginosus, (Scop.) Thurlow Island and Comox.
Sphærophorus globiferus, (C.) Thurlow Island, Hanson Island, Alert Bay and Harbledown Island.
Biatora, Sp. On moss at Knox Bay.
Biatora, Sp. On bark of trees, Hanson Island and Comox.
Endocarpon, Sp. On rocks at Comox.

APPENDIX III.

METEOROLOGICAL OBSERVATIONS ON THE COAST OF BRITISH COLUMBIA, JUNE 21ST TO OCTOBER 22ND, 1885.

The barometer readings are those of a small aneroid, but have been corrected for instrumental error and are believed to be nearly exact.

The temperature is stated in degrees Farenheit.

The force of the wind is estimated according to Beaufort's scale. The proportion of the sky covered by clouds is estimated on a scale of 0 to 10, 0 being a cloudless sky, 10 a completely clouded sky. The character of the clouds is denoted by the usual letter or combination of letters referring to Howard's classification.

PLACE.	Date.	Hour.	Barometer corrected.	Ther. corrected. Air.	Max.	Min.	Direction of wind.	Foro. of wind.	Amt. of cloud.	Kind of cloud	Temp. of surface water.	Weather at time.	Weather during last interval.
VICTORIA TO SEYMOUR NARROWS.				°	°	°							
Off Victoria	June 21	8.15 a.m.	30.27	59.	....	....	S.S.E.	I	2	C & K.	51.	Fog bank in Strs.	
Swanson Channel	" 21	7.00 p.m.	30.126	57.	....	....	E.	II	1	K & CK.	51.5	....	Light S.S.E. wind changing to E. fair.
" "	" 22	7.00 a.m.	30.22	59.	....	45.	S.	I	2	C K.	52.5	....	Light airs and calm. Fair.
Str. of Georgia off Fraser R.	" 22	7.00 p.m.	30.13	64.	69.	....	S.W.	I	4	C. & K.	64.5	Fair.	E. & S.E. lt. winds. Fair.
" " " Dep. Bay	" 23	7.00 a.m.	30.22	63.	....	....	W.	IV	7	K S.	63.5	....	Str'g W.w'd. Sea rough w'd III to IV.
" " " "	" 23	7.00 p.m.	29.97	66.	76.	....	S.W.	I	1	K.	66.5	Fair.	Calm from 9 a.m.
" " " Ballinac I.	" 24	7.00 a.m	30.01	61.	....	....	N.W.	II	½	K.	63.	Fair.	Lt. E. air 9.12 p.m. Calm 12.30. N.W. breeze from 12.30.
" " " Hornby I.	" 24	7.00 p.m.	29.87	68.	76.5	....	Variable.	0	3	C.	62.5	Fair.	Lt. N.W. wind falling calm and var.
Baynes Sound, S. end	" 25	7.00 a.m.	30.01	68.	....	59.	Calm.	....	7	C K.	61.5	....	Lt. puffs from S. followed by calm.
Comox Harb.	" 25	7.40 p.m.	29 99	67.	73.	....	S.E.	II	7	K.	65.	....	Str. S.E. wind from 10 a.m.
" "	" 26	7.00 a.m.	30.13	58.	....	52.	N.W.	I	5	K.	64.5	....	Calm nearly all night.
North end Texada I.	" 26	7.00 p.m.	30.19	64.5	....	....	E.S.E.	II	9	K S.	64.5	Shrs. Clearing.	Strong breeze since 9 a.m.
North end Texada I.	" 27	7 00 a.m.	30.24	64.	....	55.	S.E.	I	9	K. & S.	62.5	....	Lt. air S. S.E. Calm with showers.
1½ mile N, Cape Lazo	" 27	7.00 p.m.	30.09	65.	74.	....	E.	0	10	K S.	57.5	....	Lt. variable airs.
" " "	" 28	7.00 a.m.	30.07	61.	....	....	E. variab.	I II	10	K S.	57.0	....	Calm all night. Breeze in morning changing S. and E.
Oyster bay	" 28	7.00 p.m.	30.09	65.	74.	....	Variable.	0	10	K S.	62.	....	Rain till noon. Calm since 1 p.m.
Discovery Passage	" 29	7.00 a.m.	30.21	60.	....	....	N.W.	II	1	K.	60.	....	Calm all night.
Disc. Passage off Yucalta village	" 29	7.40 p.m.	30.02	74.	77.	....	Calm.	....	....	....	51.	Clear.	Very light air N.W. all day.
" " "	" 30	7.00 a.m.	....	52.	....	....	"	....	10	N.	51.5	Rn'g. very hard	Calm & lt. S. wind. Rain began 5 a.m.
Off Cape Mudge	" 30	7.30 p.m.	30.02	60.	....	....	"	....	7	K.	63.	....	Calm and light S. E. air,
" "	July 1	7.00 a.m.	30,04	58.	....	52.	N.W.	II	7	K S & C.	62.5	....	Lt. N.W. wind.

Drew Harbor	July	1	7.00 p.m.	30.00	60.5	76.		N.	II	1	K S.	60.		Lt. N.W. changing to S. wind.
" "	"	2	7.00 a.m.	30.10	59.		51.	N.	I	2	C.	64.	Fair.	Lt. N. wind.
" "	"	3	7.00 p.m.	30.20	73.	90.		N.	I		Clear.	66.		Strong N. wind in afternoon.
" "	"	4	7.00 a.m.	30.34	66.		52.	N. by E.	II		Clear.	66.		Continued strong wind chang. to S.E.
" "	"	4	7.00 p.m.	30.27	67.	89.		N.	I		Clear.	67.		Str. breeze in afternoon from N. fair.
" "	"	5	7.00 a.m.	30.29	70.		61.	N.	II			67.		Fair continued. Strong wind.
" "	"	5	7.00 p.m.	30.13	77.	88.		N.	II			67.		" " " " squally.
Mary Island anchorage	"	6	7.00 p.m.	29.97	73.			N.	IV	1	C.	52.		Light wind and fair, forenoon, heavy during afternoon.
" " "	"	7	7.00 a.m.	29.94	62.		57.	N.W.	II	8	C & K.	50.5		Blowing all night.
Stag Harbor	"	7	7.00 p.m.	29.94	72.	76.		N.	II	1	K	63.	Very smoky.	Heavy N. wind part of afternoon.
" "	"	8	7.00 a.m.	29.99	67.		62.	N.	I		K& Sm.	58.	" "	Fresh breeze all night.
" "	"	8	7.00 p.m.	29.94	69.	77.		N.	I	8	K.	62.	" "	
" "	"	9	7.30 a.m.	30.07	61.		60.	Calm.			Smoke.	57.5	" "	6 a.m. lt. S.E. breeze foll. by calm.
Malaspina Inlet, Georgina Pt.	"	9	7.00 p.m.	30.04	68.	75.		"			"	65.	" "	Slight S.W. changing to west breeze.
" " "	"	10	7.00 a.m.	30.13	62.		58.	"				56.	" "	
" " "	"	10	7.00 p.m.	30.06	68.	78.		"				64.	" "	Light W. wind in afternoon.
" " "	"	11	7.00 a.m.	30.14	60.		56.	"				59.		Calm all night.
Savary Island	"	11	7.00 p.m.	30.11	71.	90.		"			Clear.	60	Little smoky.	Light west S.W. and S.E. variable breeze. Fair.
N. Savary Island	"	12	7.00 a.m.	30.16	62.		58.	N.W.	I		"	58.	Clear.	Calm all night.
W Ragged I.	"	12	7.00 p.m.	30.07	72.	87.		Variable.	0		"	60.		Calm and clear.
Stag Harbor	"	13	7.00 a.m.	30.12	69.		61.	W.	0		"	60.		Slight breeze at midnight.
" "	"	13	7.00 p.m.	30.005	72.	78.		S.E.	III	8	K.	57.	A few d'ps of rain	Wind changed at 3 p.m.
Off Dinner Rock	"	14	7.00 a.m.	30.135	61.			N.	I			62.		Made sail 3 a.m. wind then N.W. I
Off Indian Village, Klahoos	"	14	7.00 p.m.	30.175	61.	76.		S.W.	I	9	K.	63.		Little rain at noon.
" " "	"	15	7.00 a.m.	30.155	62.		60.	N.	II	4	K.	62.5		Started at about 9 a.m. blowing fresh N. to N.W.
Thunder Bay, Jarvis Inlet	"	15	7.00 p.m.	30.135	66.	80.		Variable.	I	1	K.	66.	Fair.	Wind gradually fell chang. S.E. & S.
" " "	"	16	7.00 a.m.	30.105	70.		60.	Calm.		1	K.	63.		
" " "	"	16	7.00 p.m.	30.085	65.	76.		S. by W.	I	10	K.	67.		Blowing hard S. 11 a.m. till 3 p.m.
" " "	"	17	7.00 a.m.	30.045	63.		55.	Calm.		7	K.	63.		
N. End Texada I.	"	17	8.00 p.m.	29.965	62.	75.		S.	I	2	K S.	62.		Wind var. all afternoon.
" "	"	18	7.00 a.m.	29.935	63.		60.	N.W.	I	2	S.	62.5		Blowing hard 5 a.m. N.W.
Comox Harb.	"	18	7.00 p.m.	30.015	62.	74.		S.E. by S.	IV	5	K S.	62.		Fresh breeze during afternoon.
" "	"	19	7.00 a.m.	30.135	62.		55.	S.	0	9	K S.	62.		Rained a little about 8 p.m.
" "	"	19	7.30 p.m.	30.135	61.	74.		S.E.	III	7	C K S.	61.5		
" "	"	20	7.00 a.m.	30.165	61.		56.	S.E.	I	8	K S.	62.5		
Duncan Bay	"	20	7.00 p.m.	30.155	62.	70.		Calm.		10	K S.	52.	Rain'g moder't'ly	Brisk S.E. wind all afternoon.
" "	"	21	7.30 a.m.	30.235	61.		58.	"		2	C K S.	53.		

PLACE.	Date.		Hour.	Barometer corrected.	Ther. corrected. Air.	Max.	Min.	Direction of wind.	Force of wind.	Amt. of cloud	Kind of cloud	Temp. of surface water.	Weather at time.	Weather during last interval.
					°	°	°							
FROM SEYMOUR NARROWS TO NORTH END VANCOUVER I. AND QUEEN CHARLOTTE SOUND.														
6 miles N. Seymour Narrows...	July	21	7.00 p.m.	30.27	64.	69.	....	Variable.	0	9	K S.	50.5	....	Little rain, 2 p.m.
Elk Bay........	"	22	7.00 a.m.	30.32	57.	....	53.	....	....	9	K S.	50.	....	
" "	"	22	7.15 p.m.	30.27	60.	70.	...	Calm.	....	10	K S.	50.5	....	Showers light 6, 6.30 p.m.
" "	"	23	7.00 a.m.	30.234	56.	....	54.5	"	....	10	K S.	50.5	Foggy in Straits.	
" "	"	23	7.00 p.m.	30.164	64.	66.	....	N.W.	I	3	K S.	51.	Wind squally.	Wind rose at 1 p.m. to II squally.
Knox Harbour........	"	24	7.00 a.m.	30.214	56.	....	56.	W.	II & IV	9	K & KS.	51.	" "	Continued high wind, clouds mv'g. E.
" "	"	24	7.00 p.m.	30.174	62.5	70.	....	S.W.	II		Clear.	51.5	....	" " "
" "	"	25	7.00 a.m.	30.234	58.	....	52.	S.W.	0		"	50.	....	
" "	"	25	7.00 p.m.	30.114	68.	76.	...	S.W.	III		"	52.	....	Strong wind in straits, rose at noon.
" "	"	26	7.00 a.m.	30.144	59.	...	54.	S.W.	0	4	K.	50.	....	Clouds morning east.
" "	"	26	7.00 p.m.	30.054	64.	73.	....	S.W.	IV	3	C & S.	52.	....	Wind strong since 2 p.m. fair.
" "	"	27	7.00 a.m.	30.114	56.	....	55.	S.	0	8	K.	50.5	....	Wind very strong early part of night
" "	"	27	7.00 p.m.	30.064	62.5	....	....	S.W.	V	1	S.	52.	....	Blowing hard all day S.W. V. to VI.
Blenkinsop Bay........	"	28	7.00 p.m.	30.051	60.	....	....	S.W.	IV		Clear.	50.5	....	" " " " " " "
" "	"	29	7.00 a.m.	30.134	56.	..	54.	S.	0	7	K.	53.5	Nearly calm, fair	" " " night W. VI.
Forward Bay........	"	29	7.00 p.m.	30.114	69.	79.	...	W.	0	8	K.	50.5	....	Wind average IV. during day.
" "	"	30	7.00 a.m.	30.164	54.	....	52.	S.W.	0	10	K.	49.	....	
" "	"	30	7.00 p.m.	30.214	54.	78.	....	W.	1	10	K.	49.	....	Lt. S. W. breeze in strait.
" "	"	31	7.00 a.m.	30.284	54.	....	53.	Calm.	....	10	K.	49.5	Misty.	Rained ¼ inch commenced 10 p.m.
" "	"	31	7.00 p.m.	30.374	57.	59.5	....	"	....	10	CK & S & K.	51.	Fair.	Cleared at about 3 p.m.
" "	Aug.	1	7.00 a.m.	30.364	53.	....	54.	E.	1	7	KS & K		....	Lt. variable all day.
Off Hanson I........	"	1	7.00 p.m.	30.263	59.	69.	...	W.	III	7	K S.	54.	....	Clouds morning N.
Alert Bay........	"	2	8.00 a.m.	30.323	58.	....	56.	Calm.	....	4	K.	52.	....	
" "	"	2	7.00 p.m.	30.273	61.	66.	....	S.W.	0	1	K.	49.5	....	
" "	"	3	7.00 a.m.	30.253	53.	....	....	Calm.	....	10	K S.	48.5	Raining hard.	
" "	"	4	7.00 a.m.	30.253	55.	....	54.	"	....			49.	Thick fog.	
East end Malcolm I........	"	4	7.00 p.m.	30.253	65.	....	....	S.W.	III	10	K S.		Raining hard.	Heavy storm came up from SW 5 pm
" " "	"	5	7.00 a.m.	30.233	53.	...	52.	S.W.	(?)	10	K S.		Calm in Bay.	
Alert Bay........	"	5	7.00 p.m.	30.203	57.	78.	....	S.W.	IV	6	K S.	50.	....	
" "	"	6	7.00 a.m.	30.213	55.	....	55.	S.W.	0	10	K S.	49.5	....	
" "	"	6	7.00 p.m.	30.153	61.	83.	....	Calm.	....		Clear.	51.5	....	Lt. S.W. wind all day.
" "	"	7	7.00 a.m.	30.212	54.	....	50.	"	....	10	K S.	48.5	Raining a little.	Calm all night.
Port McNeill........	"	7	7.00 p.m.	30.202	58.	....	....	W.	1	10	K S.	54.	....	Lt. W. wind in afternoon.
" "	"	8	7.00 a.m.	30.262	58.	....	53.	W.	II	8	K S.	53.5	Clouds moving E.	Strong breeze during night.
" "	"	8	7.00 p.m.	30.222	59.	....	....	W.	IV	2	C & K.	53.	....	Strong breeze all day.

Port McNeill	Aug.	9	7.00 a.m.	30.252	56.		54.	W.	I	10	K S.	53		Lt. to moderate W & NW wind, fair.
Off Suquash	"	9	7.00 a.m.	30.272	56.5	66.		N. W.	III	1	C & S	54.	Fair.	Lt. var. winds, clear, clouding up NW
Off Beaver Harbor	"	10	7.30 a.m.	30.312	57.			E.	I	10	S.	58.5	Misty.	
Fort Rupert	"	10	7.00 p.m.	30.272	58.	66.		W.	I	1	K.	57.		Lt. wind since noon.
" "	"	11	7.00 a.m.	30.242	54.		53.	E.	0			56.5	Misty.	
" "	"	11	7.00 p.m.	30.122	62.	73.		E.	1		Clear.	57.		
" "	"	12	7.00 a.m.	30.062	57.		49.	Calm.			"	55.		
" "	"	12	7.00 p.m.	29.922	66.	75.		N. E.			"	60.		
" "	"	13	7.00 a.m.	30.031	55.		53.	E.	0		Mist.	55.	Misty.	N.W. wind falling calm and changing to S.E.
Goletas Channel	"	13	7.00 p.m.	30.221	56.5	63.5		E.S.E.	II	2	C & CS.	51.	Fair.	Lt. var. calm, misty till near noon.
Nawitti Village	"	14	7.00 a.m.	30.346	55.5					9	C K.	47.5	Fair. Some mist.	Lt. wind in forenoon, died away towards sunset.
" "	"	15	7.00 a.m.	30.321	56.		50.	S.	I	7	C& CK.	49.	" Cl'ds mv'g N.	
" "	"	15	7.00 p.m.	30.281	60.	68.		W.	I	1	C K.	50.	"	Fine and clear, very little wind out in Sound.
" "	"	16	7.00 a.m.	30.221	56.		52.	W.	I		Misty.	48.5		
" "	"	16	7.00 p.m.	30.231	59.	71.		W.	I		"	50.	Misty.	Cleared about 11 a.m., few clouds, misty at 6 p.m.
" "	"	17	7.00 a.m.	30.300	54.		53.	Calm.			"	50.5	"	Cleared about 10 a.m
Bull Harbor, Hope Island	"	17	7.00 p.m.	30.299	62.	70.		W.	I		"	53.5		Cleared about 10 a.m., fog from W. at 5.30 p.m.
" " " "	"	18	7.30 a.m.	30.199	54.		53.	W.	1		"	51.		
" " " "	"	18	7.00 p.m.	30.299	60.	73.		W.	1	1	S.	55.		Very foggy and damp till 1.30 p.m., cleared and wind IV.
" " " "	"	19	7.00 a.m.	30.409	56.		54.	Calm.		10	K S.	51.		
Off N. W. Nipple, N. 20° E.	"	19	7.00 p.m.	30.409	62.	72.		"		1	K S.	52.		Slight W. wind 10 a.m. till 3.30 p.m.
Nahwitti Cove											Clear.			
" " " "	"	20	7.00 a.m.	30.209				"						
" " " "	"	20	7.00 p.m.	30.099	60.			"			"	56.5		Calm and clear all day.
N. Cape Scott	"	21	7.00 p.m.	30.029	57.			"			Misty.	51.5		Clear till 4 p.m., slight puff of wind made 3 miles and anchored, fog.
Off " "	"	22	7.00 a.m.	30.099	56.			W. by N.	0		"	50.5	Little rain.	Clear and calm during night.
" " "	"	22	7.00 p m	30.108	57.			W.	1	8	K S.	50.5		Commencing to blow.
Hecate Cove, Quatsino Sound	"	24	7.30 a.m.	30.158	54.5		48.	Calm.		2	C.	51.5	Mist on hills.	Clear and calm during night, lt. mist.
" " " "	"	24	8.00 p.m.	30.098	58.	70.		"		1	K S.	56.		
" " " "	"	25	7.00 a.m.	30.118	57.			"		8	K S.	54.	Clouds moving E.	
" " " "	"	26	7.00 p.m.	30.298	67.			W.	1	8	K S.	57.		
" " " "	"	27	7.00 a.m.	30.328	57.			Calm.		5	S.	56.		
" " " "	"	28	7.00 p.m.	30.097	64.			"			Clear.	54.		Light E. wind in morn. chn'g. to W.
" " " "	"	29	7.30 a.m.	30.097	52.		50.	"			"	52.5	Lt. mist in Sound	
Off Limestone Island	"	29	7.00 p.m.	30.047	62.	71.		W to S W	0	5	K & S.	55.		Lt. S.W. wind since 10 a.m.
" " "	"	30	7.00 a.m.	30.117	54.		53.	Calm.		5	K.	53.		11 to 11.30 p.m. strong breeze west.
Quatsino Inlet	"	30	7.00 p.m.	30.167	58.	66.		W.	I	4	K C&S.	55.	Clouds mv'g N.E.	
North Harbor	"	31	7.30 a.m.	30.297	56.		54.	Calm.		6	K S.	55.5		
" "	"	31	7.00 p.m.	30.317	62.			E.	I	5	K.	57.	Clouds mv'g N.E.	S.W. wind outside, light.
" "	Sept.	1	7.00 a.m.	30.337	58.		56.	Calm.		7	K S.	56.	" " N.	
4 miles off Raft Cove	"	1	7.00 p.m.	30.316	63.	70.		S.	I	10	S.	56.		Wind rose in harbor 11 a.m.
Off Cape Scott	"	2	7.00 a.m.	30.236	60.		59.	E.S.E.	I	10	S & K.	54.		" S.S.E. all night, N. of Cape Scott E., land covered by fog.

PLACE.	Date.		Hour.	Barometer corrected.	Ther. corrected. Air.	Max.	Min.	Direction of wind.	Force of wind.	Amt of cloud.	Kind of cloud	Temp. of surface water.	Weather at time.	Weather during last interval.
					°	°	°							
Goletas Channel..............	Sept.	2	7.00 p.m.	30.206	62.	69.	....	W.	I	8	K S.	50.	....	S.E. breeze sprang up at noon from S., heavy.
Beaver Harbor..............	"	3	8.00 a.m.	30.136	55.	....	52.	S. W.	I	....	Misty.	51.	....	
" "	"	3	7.00 p.m	30.076	63.	67.	....	W.	1	5	C & K.	53.	....	Mist coming from W outside in chn'l.
" "	"	4	7.00 a.m.	30.076	54.	....	53.	Calm.	....	....	Misty.	52.	....	
Off Kliksewi R., near Suquash	"	4	7.00 p.m.	30.105	54.	63.5	....	S. E.	0	4	K & K S.	52.	....	N.E. wind I. changed at 2.15 p.m. to N.W. Calm 6.30 p.m.
S. Malcolm I., near Rough B..	"	5	7.00 a.m.	30.125	54.	....	....	Calm.	....	....	Misty.	48.5	....	
Alert Bay..............	"	5	7.00 p.m.	30.126	54.	65.	....	S. W.	1	10	K S.	48.	....	
" "	"	6	7.00 a.m.	30.086	54.	....	53.	Calm.	....	10	K S.	48.5	....	Calm during night. No rain.
" "	"	6	7.00 p.m.	30.055	57.	69.	....	S. W.	0	8	K S.	48.5	....	
....	"	7	7.00 a.m.	30.055	52.	....	51.	Calm.	....	4	C S.	48.	Fog bank in Str.	
Fresh Water Bay..............	"	7	7.00 p.m.	29.925	58.	64.	....	S.E. to E.	0	8	K.	48.	Clouds moving N.	Slight E. wind veering N.E. and E.
" " "	"	8	7.00 a.m.	29.715	53.	....	53.	Calm.	....	6	K.	51.	Misty in Straits.	S.E. breeze and rain about midnight.
....	"	8	7.00 p.m.	29.635	59.	....	....	S. E.	0	10	K.	48.5	Raining heavy.	Lt. showers, 11 a.m. heavy 12 noon 1 p.m. light all afternoon.
" " "	"	9	7.00 a.m.	29.695	51.	....	50.	N. W.	1	8	K S.	48.	Clouds moving E.	
Farewell Harbor..............	"	9	7.00 p.m.	29.865	50.	61.5	....	N. W.	0	1	K S.	48.	Clr'd about 8 p.m.	Few shrs. forenoon. Afternoon fine.
" "	"	10	7.00 a.m.	29.995	50.	....	46.	Calm.	....	6	CS KS.	48.5	....	
" "	"	10	7.00 p.m.	29.955	58.	71.	....	N.W.	0	6	K S.	49.	Fog in Straits.	
" "	"	11	7.00 a.m.	29.865	51.	....	51.	S. E.	0	10	K S.	48.	Few dp's. of rain.	Rained heavily early in morning and during night.
" "	"	11	7.00 p.m.	29.955	51.	63.5	....	N. W.	0	4	K & S.	48.	Clouds moving E.	Cl'd during forenoon. Wind lt. N.W.
" "	"	12	7.00 a.m.	29.725	51.	....	50.	S. E.	1	10	K S.	48.	Raining.	
" "	"	12	7.00 p.m.	29.614	53.	57.5	....	N. W.	1	10	K S.	48.5	"	Rn'd nearly all day, very heavy shrs.
" "	"	13	7.00 a.m.	29.964	50.	....	48.	Calm.	....	5	K S.	48.	....	" all night, cleared about 5 a.m.
" "	"	13	7.00 p.m.	30.044	53.	62.5	....	N. E.	1	10	S.	48.5	Raining mod'tly.	Quite clear all forenoon. Clouded during afternoon.
" "	"	14	7.00 a.m.	29.794	51.	....	48.5	S. E.	II	8	C&K S.	49.	....	Bar. fell till midnight. S.E. wind and rain, heavy 12.5 p.m.
Cullen Harbor..............	"	14	7.00 p.m.	29.674	58.	....	....	N. W.	II	8	K S.	51.	A few drops rain.	Wind in Sound. S.W. clouds coming from S.W.
" "	"	15	7.00 a.m.	29.893	48.	....	48.	W.	I	6	K S.	49.	Clearing.	Several showers during night.
" "	"	15	7.00 p.m.	29.983	55.	....	....	S. E.	0	2	K S.	51.5	....	Rained, moderate 11.30 a.m. till 3 pm.
" "	"	16	7.00 a.m.	30.213	50.	....	49.	Calm.	....	2	K S.	51.		No rain during night.
Monday Harbor..............	"	16	7.00 p.m.	30.073	....	....	....	....	....	....	....	....	Stm coming S.W.	Storm passed N. Rn'd at Cullen Hr.
Cullen Harbor..............	"	17	7.00 p.m.	30.093	56.	....	....	Calm.	....	4	K S.	49.	A few sprinkles.	A few showers during afternoon.
" "	"	18	7.00 a.m.	29.958	51.	....	51.	S. E.	0	10	K S.	49.	" "	Rained hard at 5 a.m.
" "	"	18	7.00 p.m.	30.093	54.	....	....	Calm.	....	9	K S.	50.5	....	Heavy showers in afternoon. Lt. rain all day.

Cullen Harbor	Sept.	19	7.00 a.m.	30.133	49.	....	49.	S. E.	I	9	K S.	50.	....	Lt. wind freshn'g up and blowing in st'g squalls. Heavy shrs till 2 pm.
Blunden Harbor	"	19	7.00 p.m.	29.733	53.	54.	....	E.S.E.	VI	10	K S.	53.	Occasional lt shrs	
" "	"	20	7.00 a.m.	29.798	51.5	...	....	S. W.	V	7	K S.	52.	Showery.	Lt. rain till midnight. Wind mod'rg. Heavy thunder shower 6 a.m.
" "	"	20	7.00 p.m.	30.223	52.	59.5	....	S. W.	I	9	C S & K.	55.	Clearing.	Showery.
" "	"	21	7.00 a.m.	30.222	50.	....	49.	S. E.	II +	10	K S.	53.	Sq'ly with lt rain.	
" "	"	21	7.00 p.m.	30.123	53.	...	....	S. E	II	10	K S.	52.	Dropping rain.	Rain'g steadily all day. Wind SE stg.
" "	"	22	7.00 a.m.	29.972	52.	....	52.	S. E.	I	10	K S.	52.	Lt. rain.	Showery.
" "	"	22	7.00 p.m.	29.742	61.	64.	....	S. E.	II	10	S & K S.	53.	....	Showers all day. Light.
" "	"	23	7.00 a.m.	29.717	54.	....	53.	S. W.	II	10	CK& KS.	53.5	....	Showers during night.
Between Foster I. & Malcolm I	"	23	7.00 p.m.	29.902	53.	63.5	....	Calm.	....	2	K	48.5	....	
Near Mitchel Bay	"	24	7.00 a.m.	30.012	45.	....	44.	E.	0	8	K S.	48.	....	
Alert Bay	"	24	7.00 p.m.	30.152	50.	62.5	....	Calm.	....	6	K S.	52.	Clearing.	Showers light.
" "	"	25	7.00 a.m.	30.142	49.	....	47.	S. E.	II +	7	K S & S.	48.5	Squally.	
" "	"	25	7.00 p.m.	30.007	53.	56.5	....	S. E.	V	10	K S.	48.5	Lt. rain.	
" "	"	26	7.00 a.m.	29.902	50.	....	50.	E.	V	10	K S.	48.	Clouds mv'g. W.	
" "	"	26	7.00 p.m.	29 811	52.	58.5	...	S. E.	III +	10	K S.	49.	Raining modr'ly.	Showery all day. Wind strong S.E.
" "	"	27	7.00 a.m.	30.101	50.	....	49.	S. W.	I	2	K S.	49.	....	
Beaver Cove	"	27	7.00 p.m.	30.151	51.5	63.5	....	S. in Bay.	I	3	CS& CK K S.	53.	Fair. Cld'g from S	Lit. westerly wind falling calm in evening. Scattered clouds.
" "	"	28	7.00 a.m.	30.061	43.5	..	42.	" "	I	8	CS. CK. K S.	50.	Fair.	Lt. S. wind, partly clouded, no rain.
Broughton Straits	"	28	7.00 p.m.	30.071	52.5	65.	....	E.S.E.	II	8	C S & S.	49.	Fair. Clouding.	Nearly calm till 11 a.m. Lt. E. wind all p.m. Partly clouded.
Growler Cove	"	29	7.00 a.m.	30.151	52.	..	43.5	E.S.E.	V	10	K S & S.	49.	Showery.	Strong S. E. wind, freshening to gale, with rain. Becomes clouded.
" "	"	29	7.00 p.m.	30.216	55.	59.5	...	E.S.E.	V	....	....	49.	Squally, showery	Blowing half gale S. E. all day. Shrs in p.m. Generally clouded.
" "	"	30	7.00 a.m.	30.161	55.	...	54.5	E.S.E.	0	7	K S.	48.5	"	Blowing strong SE all day. Showers.
Broughton Straits	"	30	7.00 p.m.	30.356	52.5	57.5	....	Calm.	....	8	K S&S. CK&CS	48.5	Calm and fair.	S.E. followed by lt. W. wind. Shr'y clearing 3 p.m.
" "	Oct.	1	7.00 a.m.	30.510	51.5	..	50.	"	......	9	S & mist.	49.	Mist low on hills.	Lt. var. nearly calm. Generally clouded, banks of mist, no rain.
Johnstone Straits	"	1	7.00 p.m.	30.505	51.	61.5	....	W.	II	4	C&CK S.	50.	Fair. lwr.cld. "	Calm till 3 p.m. then light W. gradually freshening. Generally clear.
" "	"	2	7.00 a.m.	30.50	48.	....	47.	S.S.W.	II	....	CK mist.	47.5	Mist low on hills.	Lt W wind dying away at 4 a.m, fol. by lt. S.E. Fair, generally clear.
" "	"	2	7.00 p.m.	30.41	58.	70.	....	Var.	0 I	8	C K.	49.	Fair.	Lt. S.E. wind falling calm 10 a.m. Lt var. and calm till evg. Clear, fair.
Otter Cove	"	3	7.00 a.m.	30.36	52.	....	49.	N. W.	IV	2	K S.	49.5	"	Lt. var. Heavy squall from W. 2 p.m fol. by str. N.W. Partly clouded.
Seymour Narrows	"	3	7.00 p.m.	30.23	58.	64.	....	N. W.	III	1	C S.	......	"	N.W. strong all day. Light clouds moving east.

PLACE.	Date.	Hour.	Barometer corrected.	Ther. corrected. Air.	Ther. corrected. Max.	Ther. corrected. Min.	Direction of wind.	Force of wind	Amt. of cloud	Kind of cloud.	Temp. of surface water.	Weather at time.	Weather during last interval.
SEYMORE NARROWS TO VICTORIA C.B.				°	°	°							
Duncan Bay..................	Oct. 4	7.00 a.m.	30.24	48.	....	48.	W.	II	1	C.	49½.	....	Clear all night, a few clouds. Wind W. II to III.
Str. of Georgia W. of Savary I.	" 4	7.00 p.m.	30.22	57.	65.	....	W.	0	....	Clear.	54.	....	Lt. N.W. changing to N.E., E. and S.W. to W., dying away.
Off Cape Lazo..............	" 5	7.00 a.m.	30.30	49.	....	48.	N.W.	0-I	6	C.	53.	Fog E. edge of str	Lt. W. changing to N.W.
Comox Harbor...........	" 5	7.00 p.m.	30.25	52.	64.	....	W.	0	2	C.S.	53.5	Fair.	Lt. N. " " N. E. in strs. Baynes Sound wind S.E. to S.
" "	" 6	7.00 a.m.	30.26	46.	....	46.	W.	I-II	1	C.S.	58.5	Fair.	
" "	" 6	7.00 p.m.	30.17	56.	64.5	.. .	W.	0	....	Clear.	56.	....	West wind died away 10 a.m. S.E. to S., lt, 10 a.m. 5 p.m. clear.
" "	" 7	7.00 a.m.	30.17	46.	....	45.	W.	1	....	"	53½.	Mist at mouth of Coventry R.	
" "	" 7	7.00 p.m.	29.99	56.	66.	....	W.	0	....	"	56.	....	Wind W., died away 10 a.m., S. lt. 10 a.m.
" "	" 8	7.00 a.m.	29.91	45.	....	45.	W.	0	4	C. K.	54.	....	
" "	" 8	7.00 p.m.	29.89	54	....	....	S. W.	1	10	K. S.	55.	....	On mts. and strs. shrs. Str. SE in pm. Heavy K.S. clouds on mts. to W.
" "	" 9	7.00 a.m.	29.96	45.	....	42.	W.	1	4	K. S.	53.	....	
" "	" 9	7.00 p.m.	30.10	47.5	....	....	W.	1	1	K. S.	53.5	....	Westerly wind all day. KS clouds on mts. Few shrs. in p.m.
" "	" 10	7.00 a.m.	30.305	40.	....	38.	W.	1	1	K. S.	52.5	Mist in harbor.	
Between Texada and Hornby I.	" 10	7.00 p.m.	30.37	53.	....	....	S. E.	1	4	K. S.	53.	Clouds moving E.	Very light wind, variable.
Off False Bay................	" 11	7.00 a.m.	30.31	48.	....	47.	E. to S	1-1	5	KS CS K.	52.	....	Calm 7-10. S.E. II ½ hour. Calm till 4.30, clear till 5 pm, clds from SE.
" " "	" 11	7.00 p.m.	30.21	50.	....	....	N.W.	I	6	K. S.	53.	....	Calm and lt. var. N. W. lt., commenced at 4 p.m.
False Bay..................	" 12	7.00 a.m.	30.11	49.5	....	48.	Var.	0	7	K. S.	53.5	A few sprinkles.	No wind noticed during night.
" "	" 12	7.00 p.m.	30.05	52.	....	....	Calm.	....	10	S & K. S.	53.		Lt. N.W. and W. wind. Heavy clds. mv'g. NE and N all day. No rain.
" "	" 13	7.00 a.m.	30.06	50.	....	50.	"	....	10	K S.	53.5	Clouds mv'g. NE.	Lt. rain during night. Lt. wind NW.
" "	" 13	7.00 p.m.	30.085	52.	62.5	....	"	....	...	Clear.	54.	....	Clearing. Lt. wind N.W. Clouds KS moving N.E. and E.

" "	Oct.	14	7.00 a.m.	30.085	50.	....	47.	S. E.	II	8	K.& K.S	54	Mist in strs.	
" "	"	14	7.00 p.m.	30.065	52.	56.5	....	SW in strs N.W.	1	0	K. S.	53½.	Rn'g. Clouds NE.	Heavy S.E. wind till 5 p.m. Ch'd. to SW 6 pm. KS clds. mvg. NW & NE
" "	"	15	7.00 a.m.	30.195	45.		42.	N.W.	I	2	K. S.	52½.	....	Cleared 9 p.m., wind S.W. 3 a.m. wind N.W. Sky clear.
" "	"	15	7.00 p.m.	30.265	48.	...	....	N.W.	I	1	K. S.	53.	....	Clear nearly all day. KS clds. N.W. to S.E. Wind III. fell at sunset.
" "	"	16	7.00 a.m.	30.245	43.	....	43.	N.W.	I	7	K. & K.S.	53.	Clouds mv'g.S.E.	
" "	"	16	7.00 p.m.	30.150	48.	66.	....	N.W.	0	10	S. & K.S.	52.5	....	KS clouds moving E. all day. Wind III N.W., dying away 5 p.m.
" "	"	17	7.00 a.m.	30.295	42.	...	40.	W.	0	6	K. & fog.	51.	....	
" "	"	17	7.00 p.m.	30.375	50	60.5	...	Calm.	....	9	K.	52.	....	Few sprinkles 9 a.m. Lt. W. to N.W. wind all day. Clouds from S & W.
" "	"	18	7.00 a.m.	30.415	49.	...	47.	N.W.	0	9	K. S.	52.	Clouds moving E.	
Strs of Georgia near Ballidrac I.	"	18	7.00 p.m.	30.285	52.	63.	....	S.W.	0	1	S.	52.	....	Lt NW wind all day, dying away 5 pm clds KS dn'g a.m. Sky clear in pm.
Off Nanaimo	"	19	7.00 a.m.	30.215	48.	....	47.	N.W.	0	2	K. S.	52.	....	Lt. N.W. and W. wind, sky clear, wind dying away at 5 a.m.
" Gabriola Reefs.............	"	19	7.00 p.m.	30.11	53.	....	....	Calm.	....	4	K. S.	53	....	Lt. S. and S.E. wind 8.30 a.m. to 6 p.m. K.S. clouds moving E.
" Portier Passage............	"	20	7.00 a.m.	30.13	49.	....	48.	E. to S.	1	8	K. S.	51.5	....	Calm and lt var. S. and W. wind.
4 miles S.E. Portier Passage..	"	20	7.00 p.m.	30.015	52.	64.	....	S.	0	6	C.S&K.S.	53.	....	Lt. S.E. 2 hrs. Calm nearly all day. Clouds from W. and S.W.
N.E. Saturna I	"	21	7.00 a.m.	30.045	51.	....	50.	Calm.	....	8	K.	51.5	Clouds from W	Lt. wind 11 p.m. to 5 a.m. KS clds. at 11 p.m. moving N.E.
Off Discovery Island..........	"	21	7.00 p.m.	30.05	53.	..	....	E.S.E.	0	3	K. S.	50.	Clouds from S.W.	Breeze N.W. 10 a.m.–4 p.m.
" Beacon Hill................	"	22	7.00 a.m.	30.065	50.	....	....	Calm.	....	....	Fog.	......	....	Lt. N. wind 10 p.m.–1 a.m.

G. W. DAWSON, PHOTO., 28TH AUG., 1881.

IVES PROCESS; GEO. E. DESBARATS, MONTREAL.

VIEW LOOKING DOWN BOW-PASS, FROM GEOLOGICAL SURVEY CAMP.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

GEOLOGICAL STRUCTURE

OF A PORTION OF THE

ROCKY MOUNTAINS,

ACCOMPANIED BY A SECTION MEASURED NEAR THE
51ST PARALLEL.

BY

R. G. McCONNELL, B.A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1887.

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to present herewith my report on an exploration in the Rocky Mountains, accompanied by a section measured in the vicinity of the passes followed by the Canadian Pacific Railway.

I have the honor to be,

Sir,

Your obedient servant,

R. G. McCONNELL.

OTTAWA, 30th April, 1887.

REPORT

ON THE

GEOLOGICAL FEATURES

OF A PORTION OF

THE ROCKY MOUNTAINS,

ACCOMPANIED BY A SECTION MEASURED NEAR THE 51ST PARALLEL.

The field season of 1886 was occupied in measuring a general section across the Rocky Mountains proper, or that division of the Cordilleran system included between the eastern outcrop of the palæozoic rocks, and the Columbia valley, and in working out, as far as time permitted, the remarkable structural features of the range. The belt of country selected for this purpose, follows the line of the Canadian Pacific railway along the Bow and Wapta (Kicking Horse) Valleys, from Banff westward to Golden City on the Columbia. East of Banff it leaves the railway and follows the Devil's Lake valley eastward to its gap* This portion of the range was examined in part by Dr. Hector, in 1858-59, and is also included in Dr. Dawson's exploration of the southern portion of the Canadian Rocky Mountains, and a description of its more prominent characteristics will be found in his report. (See Annual Report 1885, part B.) **Geographical position of section.** **Previous exploration.**

The section accompanying the present report is, as far as possible, a natural one, but the winding character of the route traversed, combined with the imperfect topography and ever varying strikes, rendered a certain amount of generalization unavoidable. A line measured at right angles to the strike of the beds, if followed for any distance, would soon diverge widely from the direction of the valley and lead into practically inaccessible regions, and it was therefore found necessary, in many cases, to jog the section for some distance along the strike, and to continue it on the opposite side of the pass. Also in **Character of section.**

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* The "Gap" is a local term used to designate the point at which any considerable valley leaves the mountains.

places where the exposures along the main line were defective or absent, the interval was filled by neighbouring parallel sections. The general section is in reality, therefore, a combination of a number of shorter ones, selected in the vicinity of the valleys followed, and measured at right angles to the local strikes. They are, however, connected along the strike in such a manner as to give as perfect a representation as possible of all the beds met with in the range.

In regard to the completeness of the work, it may be stated that while much still remains to be done in the way of filling in local details, yet the general features of the section, as presented, are believed to be fairly accurate, and will not be much modified by future investigations. In a mountainous and mostly wooded region like the one examined, where the possession of any geological fact implies a long and laborious climb of from 2000 to 6000 feet, the construction of a section showing all the structural minutiæ, becomes an arduous undertaking, and would require a much longer time than the four months or so at my disposal.

Shorter sections illustrative of special points.

In addition to the principal section a number of shorter parallel sections were also measured. These serve to illustrate special points in the structure of the range, and also show the rapid change in the character of a fault or fold when traced along the strike.

Section D–C was sketched along the northern side of the valley of the south fork of Ghost River, about two miles south of the Devil's Lake valley. It shows the Cretaceous shales faulted under the Cambrian rocks at the eastern edge of the mountains, while the same beds, or beds belonging to the same group, overlie the palæozoic series a few miles farther west.

Section E–F is drawn along the northern side of the Bow, through the Fairholme mountains, and traverses a few miles farther south the same ranges, as those shown in the principal section east of the Cascade trough.

Section G shows a Cretaceous outlier which occurs east of the same fault as that seen on the principal section, but about three miles farther north.

Sections H and K illustrate the folding of the Cretaceous beds of the Cascade trough. They were measured eighteen and twenty-three miles respectively, S.E. of the corresponding point in the general section.

Section M–S starts near the summit of Johnson Creek, and crosses the Castle Mountain range and the Bow River anticlinal, while section O–N is drawn across the same anticlinal, about eight miles farther north.

Topography.

A general description of the Bow and Hector (Kicking Horse) Passes is given in Dr. Dawson's report (see Annual Report 1885, p. 124 *et seq.*) and the following notes may be considered as merely supplementary to his sketch, and will only refer in detail to places which were not visited by him.

General description of pass.

The Fairholme Mountains comprise a group of high ridges and mountains, bounded on the east by the foot-hills, on the north by the Devil's Lake valley, and on the south and west by the Bow. On the east, they rise abruptly from the foot-hills to heights of from 2000 to 4000 feet, and face plain-wards as a massive escarpment broken by a number of deep valleys. The receding summits of the different segments are either flat-topped or crowned by ruined cliffs, due to the unequal denudation of the dolomitic limestone capping them.

Fairholm Mountains.

The western part of the group consists of ridges running parallel, or nearly so, to the Cascade trough, some of which extend, without interruption, northward from the Bow to the Devil's Lake valley. On the south, the cross section cut by the Bow, is about seven miles wide, and shows the triangular ends of such ridges throughout, but going north the group widens out rapidly towards the east, and while the western part of the section seen along the Devil's Lake valley, corresponds in a general way with that on the Bow, the eastern part shows massive square-built mountains of a totally different character, and due to an entirely different set of geological conditions.

Wherever the beds are tilted to any considerable angle, so as to expose the upturned edges of the different limestone and shaly formations, their unequal resistance to denudation is marked by the formation of deep valleys running lengthwise with the chain, separated by high limestone ridges, which are very persistent and are cut only by the more important lines of drainage. The projecting crests of these ridges are usually narrow and worn into a series of jagged peaks of a nearly uniform height, united by thin, zigzag knife-edges, on which it is often difficult to obtain a footing. In most cases, as in the Cascade Mountain range, such ridges possess a single serrated crest only, but in others, as the Sawback Range, several such lines are present. The appearance of one of these compound crested ranges, viewed from one of the higher peaks, is wild in the extreme, and is characterized by the sharply angular and pointed shapes of the profiles, and the entire absence of rounded outlines. On the other hand, wherever the beds are horizontal, or nearly so, the ridge system no longer prevails, and the four or five thousand feet of rock, rising above the base-level

Ridges formed by tilted beds.

Character of mountains where beds are horizontal.

of erosion in the valleys, is cut into irregular-shaped, steep-sided blocks, terminating in blunt or flat summits, or covered with broken cliffs. Mountains of the first description are the prevailing feature in the eastern ranges, while towards the summit they become largely replaced by those of the second. In the Fairholme Mountains examples of both kinds are present. The western part, as previously stated, consists of parallel ridges, while near the gaps of the Devil's Lake valley and the south fork of Ghost River, good illustrations of the broad-based and cliff-bounded type of mountains, resulting from the wear of heavily bedded limestone lying in a horizontal position, may be seen.

Large basin.

Another feature of this group worth noticing, is the existence, near its centre, of a considerable basin, shut in on all sides, except towards the north, by high limestone cliffs, and rising at one point into a high, flat-topped plateau, which forms the drainage centre of the district. To the east, the south fork of Ghost River, originating in a small lake lying immediately east of the plateau just mentioned, has cut an almost direct way out of the mountains. On the west, the Grotto Mountain range is broken through by a stream flowing to the Bow, and smaller streams starting here flow north and south between the ranges. This system of valleys ramifies in all directions, and affords easy access to every part of the group. Some of its members are of large size, and one ceases to wonder at the proportions of valleys occupied by large, swift streams like the Bow, and to seek for causes other than river erosion to explain their existence, when it is seen that this agent alone, —or with possibly some glacial assistance,—has been able, in the case of a small intermittent stream, only a few miles in length, such as the south fork of Ghost River, to cut out through hard limestone rocks a valley 3000 to 4000 feet in depth, and with a breadth of bottom in places of over a mile. Most of the valleys in this district, especially in their lower parts, are wide and filled with shingle, beneath which the water flows, and except in exceptionally heavy floods, no water appears on the surface. In the latter part of summer the circuit of the group might be made without crossing a single running stream, although on all the higher peaks patches of snow exist throughout the year. The small streams flowing from these, as soon as they reach the main valley, sink in the gravel and disappear.

System of valleys.

Shingle in valleys.

Streams dry up in autumn.

Height of mountains.

The mountains of the Fairholme group seldom exceed 9000 feet in height, and range from that down to 7000 feet. The highest peaks occur near the north-west corner in the neighbourhood of Mount Peechee. Towards the Bow the ranges decrease in height. One of the most prominent peaks, seen from the south, is situated about four miles north-west of Lac des Arcs, or the Bow Lake, and is interesting geologically on account of its anticlinal structure, a rare

Anticlinal mountain.

occurrence in the region. The Lower Banff limestone, here composed of a series of massive limestone beds, bends sharply over its summit, and descending the western slope with many undulations, is faulted off near the base of the mountain. The troughs of the secondary folds are filled with reddish weathering shales, and the whole section at first sight has the appearance of a series of alternating bands of shale and limestone.

Devil's Lake Valley.

The Fairholme Mountains are terminated on the north by the Devil's Lake valley, a wide, steep-sided, streamless depression now partially occupied by the Devil's Lake. This valley extends from the cascade trough east to the foot-hills, and joins Ghost River a mile or so from the mountains. Some barometer observations taken by Dr. Dawson in 1883, but which have only recently been worked out, show that this valley has a westerly inclination, and that the surface of Ghost River, at the point where it flows past the gap of the Devil's Lake valley on its way to the Bow, is considerably higher than the surface of the lake. This fact would seem to indicate that at some former period, Ghost River, after leaving the mountains, re-entered them again by this valley and joined the Bow at Banff. Its change of course, like that of most streams in the country which have suffered similar diversions, is probably due to a damming of its channel during the glacial period, and the necessity thus imposed upon it of seeking a discharge in a different direction.*

Westerly inclination of Devil's Lake Valley.

The Palliser Range is situated north of the Devil's Lake valley, and is simply a continuation of the subordinate ranges of the Farnholme group, and is of like character. It is almost cut in two by the valley of Ghost River, which enters the mountains a few miles north of the Devil's Lake valley, and runs parallel to it for some distance, until it meets a band of soft shales, along which it is deflected to the north. Among the more conspicuous peaks of this range, are the Devil's Head, which presents a vertical tower-like face towards the plains, but slopes gradually to the west, and a conical peak rising from a ridge about three miles north of the western portion of Devil's Lake, which is as yet nameless.

Palliser Range.

Ghost River Valley.

Devil's Head.

West of the Fairholme and Palliser mountains, is a wide straight valley, running in a north-westerly direction. It is followed by the Bow for about sixteen miles, and by tributaries of this stream for a much longer distance, and also by a number of other smaller streams in its further extension north and south. This great valley owes its origin to the relatively soft character of the Cretaceous shales by which it is underlaid. It has been called the Cascade trough by Dr.

Wide valley.

Cascade trough.

* For a complete description of the Devil's Lake and valley, see Annual Report 1885, p. 141 B-143 B.

Dawson, and is fully described in his report (see p. 126 B-134 B of Annual Report 1885). West of the Bow it is bounded by the Mount Rundle range, and farther north by Cascade Mountain, both belonging to the single crested type of longitudinal ridges.

Cascade Mountain. The Bow Valley leaves this basin at Banff, and turning in a westerly direction breaks through a second system of parallel ridges, almost at right angles. Cascade Mountain, the most easterly of these, rises to a height of 9730 feet above the sea, or 5200 above the surface of the valley. Its outline as viewed from the Bow is roughly triangular, and the inclination of its curved western face is almost identical with that of the limestone beds of which it is formed. Its western face is banded by steep cliffs, marking the points at which the massive beds of the upper and Lower Banff limestone come to the surface, while the alternating shaly bands are worn to easier slopes. **Mount Rundle.** Mount Rundle, south of the Bow, is a continuation of the same range, and possesses similar characteristics.

Forty-mile Creek. The range west of Cascade Mountain is unnamed, but may for convenience be called the Vermilion Lake range, from the name of a lake lying between it and the Bow. It is separated from Cascade Mountain by Forty-mile Creek, a swift mountain stream, about fifty feet broad. This stream has a somewhat tortuous course. Traced up from its mouth, it first runs for some distance along the western base of Cascade Mountain, from which it cuts off a spur, then bending to the west it breaks through the Vermilion Lake range to the next valley, along which the main stream continues to its source, while a tributary which it receives from the west interlocks with a branch from Johnson Creek, and forms a rough but practicable pass across the Sawback Range. South of the Bow the Spray River repeats in an opposite direction the course of Forty-mile Creek.

Vermilion Lake range. The Vermilion Lake range is surmounted by two prominent notched ridges, rising about 4,000 feet above the valley, and separated by a narrow valley due to the more rapid weathering of a band of shales which separates the two peak-forming limestone bands. Terrace Mountain, the segment of this range south of the Bow, is somewhat narrower, and is terminated by a single crest.

Hot springs. Around the north-eastern base of this mountain are situated a number of hot springs, which are reported to possess remarkable medicinal properties, and have already attracted large numbers of health-seekers. The country around has been reserved for a national park, and during the past summer a number of good hotels have been erected, and roads connecting the springs with the railway station and with all the objects of interest in the neighbourhood have been surveyed and partly built.

Temperature of water. The water in the principal spring has a temperature of 111° F. in

summer, but is said to rise to 119° in winter. The lower temperature in summer may be caused by the water being affected to some extent by the surface drainage, which is more active at that season. It has a regular flow, and is forced up in large quantities through an aperture several inches in diameter. It is highly charged with mineral matter, and has deposited thick beds of calcareous tufa in the vicinity.

A number of other springs occur close by, among which may be mentioned one which rises and forms a small shallow pool in the bottom of a cave. The cave is about thirty feet deep, and is reached by an opening in the roof. The water rises through quicksands, and its ascending force is just about sufficient to prevent a man from sinking through the yielding floor. It escapes through an opening in the side of the cave, and issuing shortly after from a hill-side, is collected into a second pool, which, on account of its moderate temperature, has become a favorite resort for bathers. Spring in bottom of cave.

The springs are closely connected with a great fault which runs along the eastern base of Terrace Mountain, with a displacement of over 5000 feet. There is no evidence of either recent or ancient volcanic activity in the neighborhood, and the warm condition of the water is undoubtedly dependent on the depth from which it is derived. Springs connected with fault.

West of Terrace Mountain and the Vermilion Lake range, and separated from these by deep valleys, is the Sawback Range, the westernmost of the great series of tilted limestone ridges which constitute the dominant scenic feature in the eastern part of the chain. It is between two and three miles wide, and is composed of about 11,000 feet of strata, dipping at angles of 65° and over, and varying in hardness from quartzite and crystalline limestone down to soft shale. Every degree of relative hardness is now distinctly marked by the unequal denudation which different beds have undergone. The softer bands have sunk into deep, irregular furrows, while the more resisting beds thrust themselves up in long lines of sharp-pointed peaks. The massive beds of the Lower Banff limestone are especially noticable in this connection, and form the most persistent line of peaks in the range. At the western edge of the valley separating the Vermilion Lake range from the Sawback Range, but standing somewhat apart from the latter, is a remarkable looking group of peaks, built of upright beds and terminating in thin wedge-like summits. They are arranged in a line parallel with the main range, and the sharp outline of the most southerly member of the group forms a striking object viewed from the Bow Valley. Sawback Range. Effect of denudation. Remarkable looking line of peaks.

The Hole-in-the-wall is a name given to a cavity in the steeply sloping beds which form the western face of the Sawback Range. It is about 1500 feet above the surface of the valley, and was reported to be Hole-in-the-wall.

inaccessible, but no difficulty was experienced in scaling the steep, rocky slope leading up to it. It is, however, hardly worth the trouble of the climb, as walls and roof are bare and no stalactites or other objects of interest are to be seen. This cave has a roughly circular aperture, estimated to be about sixty feet in diameter, but going back the floor rises rapidly, and cuts off further progress at a distance of about 130 feet. It has probably been excavated by waters, descending between the almost vertical limestone beds, making an exit here.

The continuation of the Sawback Range south of the Bow was not examined.

Direction of the Bow Lakes.

After breaking through the Sawback Range, the Bow Valley bends again to the north-west, and then runs almost straight to its source in the Bow Lakes. Its course is at first somewhat oblique to the general strike of the ranges, but afterwards becomes coincident with it, in consequence of a change in the direction of the latter.

Johnson Creek.

The Sawback Range is bounded on the west by a deep valley leading from the Bow to the Red Deer, and, like most of the longer longitudinal valleys, followed in different parts of its course by a number of different streams. Near the Bow it is occupied by Johnson Creek, a swift, rocky, mountain stream, about seventy-five feet wide near its mouth, and having a total length of about sixteen miles. The entrance to the valley is blocked by a high ridge, crossing it in a diagonal direction from Castle Mountain to the Sawback Range, through which Johnson Creek has cut a deep, narrow passage to the Bow. Beyond this ridge the valley opens out, and is generally wooded for some miles, though showing small prairie patches near the stream. Approaching the summit, the trees gradually thin out and finally disappear near the base of the last steep ascent, and the surface becomes covered with grass and low shrubs. The appearance of this part of the valley in early summer is singularly beautiful, and is surpassed by few places in the mountains. Its green and partly wooded floor is bounded on the west by the massive face of Castle Mountain, which here rises in sheer cliffs, broken at intervals by ledges and *cirques*, supporting thick fields of ice, and contrasts strangely with the aerial peaks of the Sawback Range, which look down into the valley from the east. The effect of the picture on the observer is also strengthened by the frequent sound of falling avalanches echoing along the valley.

Beauty of valley.

Baker Creek.

On the farther side of the summit a rapid descent is made along a branch of Baker Creek. A few miles further on, this is joined by a stream coming in the opposite direction, and the two, after uniting, bend to the south and force a passage through the Castle Mountain range.

Castle Mountain Range.

Castle Mountain range is built of nearly horizontal limestones, and is

a cliff-bordered, oblong block, between two and three miles wide and about thirteen miles long. Its narrow ends are further split by deep valleys, of which the eastern one holds a couple of small lakes. The *massif* of this range, viewed from the Bow, is particularly imposing, owing to the long, wall-like, unbroken front which it presents in that direction. It rises to a height of 4500 feet above the Bow.

Pilot Mountain

Pilot Mountain, south of the Bow, is situated in the strike of Castle Mountain range, and has a height of 5000 feet above the valley. It culminates in a narrow, flat summit, about half a mile long, and forms the end of a rugged range extending from Healy's Creek to Red Earth Creek. It supports a small glacier on its northern slope, the first of any size met with in ascending the pass.

Watershed range.

The watershed range, across the Bow from Castle Mountain, is less regular, and its front has been dissected by numerous glacier-fed streams into short transverse ridges. The higher limestone peaks are here situated some distance back in the range, and are flanked by lower quartzite elevations. To this range belong the loftiest peaks seen along the pass, amongst them being Mt. Lefroy, which carries its snow-clad summit up to a height of 11,658 feet, and a host of others, little if at all inferior.

Valleys occupied by glaciers and lakes.

The valleys between the transverse ridges, referred to above, are usually occupied for some distance from their summits by glaciers, and often enclose small but beautifully clear lakes. Emerald Lake, one of the most accessible of these, is situated about two miles west of Laggan. It is about a mile long and half a mile wide, and is closely hemmed in on both sides by steep quartzite cliffs. It is fed by a small stream, which issues about a mile farther up the valley from the front of a glacier.

Transverse valley.

A few miles beyond Laggan the railway leaves the Bow and follows a wide valley, which here leads through the watershed range, and connects the eastern and western drainage systems. This valley is followed in its eastern part by Noore's Creek, flowing into the Bow, and in its western part by the Wapta (Kicking Horse) River, a tributary of the Columbia.

Wapta River.

The Wapta River finds its immediate source in a lake of the same name, but is joined and largely increased, a short distance from its origin, by two streams issuing from the glaciers of the Waputtehk Mountains. Its descent is at first headlong, and in less than five miles it falls over 1100 feet. Beyond this it becomes, for some miles, less rapid, and flows by several winding channels through a wide gravelly bottom. A mile and a half below Field its bed contracts again, and for some distance the stream is constantly interrupted by falls and rapids. A number of short cañons occur in this part of its course, and in one place the

Natural bridge. river is spanned by a natural bridge. In the next few miles it is joined by a couple of large tributaries from the north, and also by the Otter-tail Creek from the south, and becomes swollen to a full-sized river. Farther down it is joined by the Beaver-foot, and then, after falling over a precipice about forty feet high, it bends sharply to the north-west, and cuts a channel obliquely through the Beaver-foot Range to the Columbia. The length of the Wapta, between Wapta Lake and the Columbia, is a little over forty miles, and in this distance it has a fall of 2650 feet.

Length of the Wapta.

Ridges on western slope of mountains. The western slope of the Rocky Mountains, like the eastern, is characterized by a system of longitudinal and approximately parallel ridges. The ridges here, however, are mostly formed of beds either lying flat or dipping at low angles, and as a consequence are usually broader, and are also separated by wider intervals than is the case to the east. The Bow or watershed range has been already referred to in connection with a previous description. It is built of heavily-bedded limestone, and has been carved by a complex drainage system into a series of high, massive-looking mountains, of which Mount Stephen forms a good example. The central parts of this range are covered throughout the year by extensive snow-fields which send tongues of ice down all the principal valleys.

Snow-fields.

Otter-tail Range. West of the Bow Range is the wide valley of the Otter-tail, and across this the Otter-tail Range. The latter is crowned by a number of high, impressive-looking peaks, some of which rise over 6000 feet above the valley. It is continued north-west across the Wapta by Mount Hunter and the Van Horne Mountains. Mount Hunter is terminated by a narrow, deeply-notched edge, and resembles the ranges in the eastern part of the chain in being formed of hightly tilted limestone beds. The line of ranges just mentioned is bounded on the west by a long, straight valley, followed in the upper part by the Beaver-foot River, and farther down by the Wapta, and west of this comes the Beaver-foot Range, the most westerly range of the chain. The Beaver-foot Range has a basal width of above five miles, but slopes upwards into a single zigzag line of sharp limestone peaks. The higher summits of this range exceed 5000 feet in height.

Mount Hunter.

Beaver-foot Range.

Elevations of stations. Elevations of the stations along the Canadian Pacific Railway, in the Rocky Mountains:

The Gap	4198
Canmore	4253
Duthil	4342
Banff	4531
Silver City	4624
Eldon	4782
Laggan	5005
Stephen	5296

Hector	5177
Field	4026
Ottertail	3664
Leanchoil	3557
Palliser	3250
Golden City	2539

DESCRIPTION OF FORMATIONS.

The various formations occurring along the Bow and Wapta Valleys, have been divided, chiefly on lithological grounds, into seven groups, and as none of these can be correlated exactly with those found in the southern part of the range, as described in the various United-States reports, it has been found necessary to introduce some new terms. The following table exhibits the scheme adopted, as well as the equivalents in the ordinary classification, so far as the fossil evidence at hand admits:

Classification of formations.

Mesozoic, 5000 ft. (min)	Cretaceous	Kootanie Group to Benton	Dark shales, with some sandstones, quartzites and conglomerates.
Palæozoic, 29,050 ft.	Carboniferous passing downwards into Devonian	Upper Banff shales	Reddish-weathering and usually calcareous shales, and quartzites.
		Upper Banff limestone	Moderately crystalline, greyish limestone, often cherty and crinoidal.
		Lower Banff shales	Calcareous shales and shaly limestone.
		Lower Banff limestone	Bluish compact limestone.
	Devonian	Intermediate limestone	Brownish, irregularly hardened dolomites, and greyish, crystalline dolomites, with some sandstones and quartzites.
	Silurian	Halysites beds	Greyish dolomites and quartzites
	Cambro-Silurian	Graptolitic shales	Dark fissile shales.
		Upper part of Castle Mountain group	Mostly shaly limestones, and calcareous dolomitic argillites.
	Cambrian	Lower part of Castle Mountain group	Massive dolomites with some shaly limestone, the latter sometimes schistose.
		Bow River group	Argillites, usually dark-coloured but sometimes greenish and purplish, with quartzites and conglom'tes.

The Cretaceous.

Cretaceous.

The Cretaceous is essentially a clastic formation, and contains beds ranging through every degree of coarseness, from fine-grained fissile shales to heavy conglomerates.

Transverse ridges.

The most favorable localities for examining it are found in that portion of the Cascade trough extending from the Bow to the Kananaskis. Here, the western part of the valley is crossed transversely by a series of short ridges, the summits and steep eastern slopes of which are almost bare, and show connected sections several thousand feet in extent. Only the middle portion of the formation is, however, seen in these sections, as the lower beds are faulted off on the western side of the trough, and are concealed, and probably faulted also, on the eastern side, while the upper beds have been removed by denudation. The beds remaining do not measure over 5000 feet at the most.

Only middle portion of formation seen.

Rocks in lower part of series.

The lower part of the series consists mainly of beds and bands of flaggy sandstone, alternating with dark shales. The shales are usually somewhat arenaceous, and pass gradually, by the addition of more sandy material, into pure sandstone. They are also occasionally carbonaceous, and in a number of places enclose coal-seams, some of which are workable. The sandstone occurs, characteristically, in somewhat thick beds, and is usually coarse-grained and soft, but harder quartzitic beds are not altogether absent. It weathers to a dull red colour. The bands of sandstone are little persistent, and if traced along their strike for any distance are found to break up into subordinate beds, separated by thin shaly partings, or to pass altogether into shales. The upper part of the section contains some conglomerate, in addition to the shales and sandstone. This occurs in massive beds, measuring up to 150 feet in thickness, and is composed of rounded siliceous pebbles, with some shaly and calcareous grains, imbedded in a hard siliceous matrix. The pebbles are usually small, seldom exceeding an inch in diameter, and the rock passes insensibly into sandstone. The section here is more arenaceous than is usually the case, and there is reason to believe that it occupies a comparatively high position in the series, and that the lower part contains a greater proportion of shales. The Cascade River section, a few miles further north, which is undoubtedly lower, shows no conglomerate, and the sandstones are also of less importance, and in nearly every case where beds of Cretaceous age overlie the Banff limestone in an undisturbed condition, showing that the base of the formation is present, they consist almost entirely of dark shales.

Conglomerate in upper part.

In addition to the Cretaceous of the Cascade trough, outliers of this age occur in a number of places along the eastern side of the two principal faults traversing the Fairholme and Palliser ranges, and are often found occupying the summits of the longitudinal passes, the lower parts of the valley having been worn down to the lower beds by denudation. These outliers are all small, and the beds exposed consist of a few hundred feet of black shale, passing downwards into quartzites. No Cretaceous has been found west of the Cascade basin. The resemblance, however, between it and the upper shales of the Banff Series, which underlie them, is so close that it becomes impossible in many places to separate them without fossil evidence, and it is possible that the upper parts of some of the shaly bands which have been referred to the latter may be of this age. Cretaceous outliers. No Cretaceous west of Cascade Basin.

The following fossils were collected near the base of a small Cretaceous outlier situated three miles north of the east end of Devil's Lake:—*Oxytoma mucronata*, *Trigonia intermedia*, *Trigonoarca tumida*; all three characteristic of the Queen Charlotte Island series, and species of *Terebratula*, *Ostrea*, *Camptonectes*, *Lima*, *Cyprina*, *Ammonites* and *Belemnites*. Fossils in Cretaceous.

A small collection, obtained from the shales faulted under the Cambrian limestones at the gap of the south fork of Ghost River, includes amongst others, such Benton species as *Scaphites ventricosus*, and possibly *S. Warreni*, and an *Inoceramus* like *I. undabundus*.

The Banff Limestone.

The Cretaceous is underlaid by the Banff limestone of Lower Carboniferous or Upper Devonian age, and, notwithstanding the complete absence of all the intervening formations, no unconformity was anywhere detected between them, except where faulting is known to have occurred. The apparent conformity is perfect, even in the clearest sections, and the difficulty in drawing an exact line between the two series is further increased by the close lithological resemblance which the upper part of the Banff limestone bears to the lower beds of the Cretaceous. Banff limestone. Apparent conformity.

The Banff limestone series has a total thickness of about 5100 feet, and is divisible into a lower and upper limestone, and into lower and upper shales. Thickness of Banff series.

The upper shales vary in thickness from 500 to 1500 feet, but are usually in the neighborhood of 700 feet, and where this is much exceeded, as at the mouth of Johnson Creek, there is reason to suspect that some of the Cretaceous beds are included with them. They exhibit great diversity in structure, and pass, according to the amount of arenaceous Upper Banff shale.

matter present, from finely fissile shales, through flaggy and ordinary sandstone, into hard quartzite. The quartzites, where present, occupy the lower part of the division, and are overlain by the shales, and the two sets of beds in this position can occasionally be traced from one end of a range to the other. In other cases, however, this regularity is wanting, and shales constantly pass into quartzites, and *vice versa*. These shales are often calcareous or dolomitic, and in places are represented by an impure limestone, and they always contain sufficient iron to give them a reddish color when weathered. They are found on the western slopes of most of the ranges in the eastern part of the chain, and also in the bottoms of most of the longitudinal valleys of the same district, as from their relative softness they are one of the valley-making formations of this part of the range, an office which they fill in common with the Cretaceous shales. The Upper Banff shales are underlain by about 3000 feet of limestone, which may be called the Upper Banff limestone, in order to distinguish it from the lower limestones of the same series. This usually occurs as a greyish purely calcareous and well crystallized rock, but is also found under a number of other forms. It is often dolomitic, and hard, bluish, compact beds are not uncommon, nor are shales and sandstones altogether absent. Its most characteristic features, however, are the abundance of crinoidal remains which it everywhere shows, (some of the beds being wholly composed of the broken stems of Crinoids,) and the cherty concretions which are distributed through it, either irregularly or arranged in lines along the bedding. These concretions are especially abundant in Pilot Mountain and along the western side of the Sawback Range, and in both these places are often united into thin, irregular beds. They also become more numerous towards the top of the limestone, and are occasionally continued on into the shales.

Position of shales. **Upper Banff limestone.** **Character of limestone.** **Crinoidal remains and cherty concretions.**

Below these limestones come from 500 to 700 feet of shales and shaly limestone, constituting the Lower Banff shales. The shales are dark colored, but usually weather red, and are somewhat arenaceous, and pass into flaggy sandstone. They are also nearly always calcareous, and in places the series is represented altogether by impure, shaly limestones. At a point about two miles up a small creek, which joins the Bow from the north a short distance above the Bow River gap, this group is underlain by from fifteen to twenty feet of coal-black fissile shales, which rest directly on the massive limestone beds of the underlying formation, and are interesting on account of their fossiliferous character. A number of specimens of a *Clymenia*, besides other fossils, were collected here. At one point these black shales bend around a large and well-rounded limestone boulder, belonging apparently to the Castle Mountain group, and looking exactly like an eratic of the glacial drift.

Lower Banff shales. **Black fissile-shales.** **Rounded boulder.**

The lowest division of the Banff limestone consists of from 600 to 800 feet of heavily-bedded bluish and fairly compact limestone. In composition it is mostly calcareous, but it also contains a certain amount of dolomitic matter distributed in an irregular manner through the beds, and evidently collected together by concretionary action. The dolomite is not visible on a fresh fracture, but, owing to its superior durability, it projects from weathered surfaces, over which it often forms a rough reticulation. This limestone differs from the Upper Banff limestone in being darker, more compact, and in the smaller number of crinoidal fragments and cherty concretions which it contains, although neither of these are altogether absent. It is very evenly bedded, and weathers into bold cliffs, such as are seen in Tower Mountain on Devil's Lake, in Cascade Mountain, and in a number of other places. Lower Banff limestone.

The Banff limestone is the principal constituent of all the longitudinal ranges east of Castle Mountain. It is found in the western part of Pilot Mountain, and forms the principal mass of the Vermilion Lake range and of Cascade Mountain. East of the Cascade trough, it is found in the Grotto Mountain range and all along the Devil's Lake, but is replaced, soon after passing the end of this lake to the east, by the Intermediate limestone and the limestones of the Castle Mountain group. It ends abruptly against a fault east of Castle Mountain, and although it reaches that point from the east with undiminished volume and shows no signs of thinning out, is not seen again all the rest of the way across the range, and seems to have been entirely swept away by the tremendous denudation to which the whole chain, but especially the western part, has been subjected. Distribution of Banff limestone.

The fossils of the Banff limestone show both Devonian and Carboniferous forms, and include a *Rhynchonella* like *Rocky Montana*, another like *R. metallica*, *Atrypa reticularis*, and a *Spirifera* like *S. Whitneyi;* also species of *Athyris*, *Productus*, *Lichas*, *Eridophyllum* and *Diphyphyllum*. A large number of other species have been obtained, but these have not yet been studied. Fossils.

The upper shales of this series have yielded some *Aviculopectens* and *Lingulæ*.

The Intermediate Limestone.

The Intermediate limestone underlies the Banff limestone conformably, and passage beds partaking of the lithological character of both groups occur at the junction of the formations. It is mainly composed of a great series of brownish dolomitic limestones, and has a thickness of about 1500 feet. The typical dolomites of this formation are dark-brownish in colour, are finely crystalline, and Intermediate limestone. Thickness of intermediate limestone.

Character of intermediate limestone.

are often irregularly hardened by concretionary action. They have, in many places, a blotched appearance, due to small cavities becoming filled with calcspar, are cherty, and are characterized throughout by an abundance of corals. In some sections a light-greyish variety is not infrequent. It is more coarsely crystalline than the dark variety, and is unfossiliferous. In addition to the dolomites, beds and bands of sandstone, quartzite, and calcareous limestone, are found all through the series. A light-yellowish siliceous band, varying in thickness from 100 to 400 feet, occurs near its base, on the south fork of Ghost River and along the eastern part of Devil's Lake valley, and is also found at the entrance to the White Man's Pass.

Siliceous band.

Section near gap of Bow.

A good section across this series was obtained in the first range, near the gap of the Bow. Here it dips to the west, at an angle of 40°, and is enclosed between the Castle Mountain and Banff limestones. The former, at this point, is terminated above by some shaly, non-dolomitic limestone, overlying which, is about forty feet of reddish and bright yellowish, weathering sandstones and quartzites, forming the base of the intermediate formation. Above these come several hundred feet of brownish-weathering, irregularly hardened, magnesian limestone, holding chert and corals, succeeded by light-coloured, regularly bedded, crystalline dolomites. The latter grade upwards into a series of alternating beds of the two last varieties, associated with some beds of quartzite. Then comes a small band, consisting of soft greenish crumbling argillaceous sandstone, and hard, yellowish-weathering quartzites, overlying which are twenty feet of greyish, limestone. This limestone is succeeded by magnesian limestones and quartzites, above which come about fifty feet of heavily bedded, brownish weathering dolomites, forming the top of the series, and underlying the bluish massive beds of the Banff limestone. This section affords a fair general illustration of the relative lithological importance of the different members of the series, but could not be even approximately duplicated half a mile away, owing to differences in local detail.

Distribution of intermediate limestone.

The Intermediate limestone is first met with at the gap of the Bow, and runs from that point, in an undulating manner, towards the Devil's Lake valley, which it crosses about two miles east of Devil's Lake. In this exposure there is a general width of about three-quarters of a mile, but this is greatly increased in places in consequence of the beds flattening out and forming a capping to the series of short transverse ridges existing between the streams issuing from the mountains. A second band occurs near the western end of Lac des Arcs, and runs as far north as Bow Mountain, where it is concealed by an anticlinal fold in the Banff limestone. A short band also crosses Devil's Lake,

about two miles east of its western end, and extends a couple of miles each way. It is next met with along the western edge of the Cascade trough, overlying the Cretaceous shales, and forming the lower part of the cliff portion of Mount Rundle and Cascade Mountain. Still going west, the limestones of this group are found in the eastern slopes of Terrace Mountain and the Vermilion Lake range, and further west form the central portion of the Sawback Range. They make their last appearance in Pilot Mountain, where their volume is as great as at the gap of the Bow, and in the ridge extending from Castle Mountain to Johnson Creek. Beyond this point they disappear as completely and as suddenly as the Banff limestone. Sudden disappearance.

The fossils of the Intermediate limestone are usually badly preserved and consist mainly of almost structureless corals. Fossils.

Halysites Beds.

The only formation common to the eastern and western part of the Rocky Mountains, along the Bow and Wapta Valleys, is the Castle Mountain group, which is of Cambrian age, and will be described farther on. This group is overlaid, in the eastern ranges, by the Intermediate limestone just referred to, and in the west is continued upwards by the Graptolitic shales and the Halysites beds. Halysites beds.

The Halysites beds consist of about 1300 feet of dolomites and quartzites. This is, however, a minimum estimate of the total volume of the formation, as the upper part in this region has been removed by denudation. The quartzites occupy the lower part of the series, are usually light coloured, and occur in even, massive beds, which break into large rectangular fragments on exposure. The great angular blocks of quartzite which strew the valleys of the lower part of the Wapta, and of Horse Creek and Fifteen-mile Creek (both of which flow into the Columbia south of Golden City), are derived from these beds. The quartzites are somewhat dolomitic in places, and often pass gradually into the overlying dolomites. Thickness. Character of quartzites.

The dolomites are very evenly bedded, and vary in colour from light grey to bluish, and in texture from a compact to a moderately crystalline condition. They contain little iron, and the darker varieties weather to a dull, neutral grey. The lighter coloured varieties seem to be more ferruginous, and often show pale yellowish surfaces. This series of dolomites differs from those of the Intermediate limestone, to which it is most closely related, in being more evenly bedded, less ferruginous, and in the presence of its characteristic fossil *Halysites catenulatus*, which occurs in great abundance in some of the beds. Character of dolomites.

Distribution of Halysites beds.

The Halysites beds appear to have a very limited distribution, and have as yet only been found in disconnected strips along the central and more elevated parts of the Beaver-foot Range and its continuations. They are most available for study in the cañon of the lower part of the Wapta, where they form part of a closely appressed overturned synclinal, and descend below the level of the valley. Going south along the range, they gradually flatten out, and opposite Palliser, were only found in the summits of the higher peaks. The beds of this series have never been found in contact with the Intermediate limestone, and the lower position assigned them is entirely on the evidence of fossils.

The fossils of this formation consist of *Halysites catenulatus*, *Favosites*, a coral like *Zaphrentis*, and some badly preserved brachiopods.

The Graptolitic Shales.

Graptolitic shales.

The Graptolitic shales occupy an intermediate position between the Halysites beds and the Castle Mountain group, into both of which they appear to graduate. They have a thickness of about 1500 feet in the Beaver-foot Range, south of Palliser, but thin out considerably going north towards the Wapta cañon. They consist, as a rule, of hard black or nearly black shales are very fissile and separate easily into regular slate-like laminæ, but sections are also found showing much disturbance. The two arms of the overturned synclinal of the Beaver-foot Range, previously referred to in connection with the Halysites beds, differ markedly in this respect in the Wapta section. The upper and overturned limb is regularly and evenly bedded, and is rich in graptolites, while the lower one has been greatly crushed and corrugated and all traces of fossils obliterated. In some sections the shales alternate with small beds of limestone, and near the top are occasionally associated with quartzites and dolomites.

Thickness. Character. Overturned synclinal.

Graptolitic shales not found in eastern part of mountains.

The Graptolitic shales, like the Halysites beds, which they accompany, have not been detected in the eastern part of the mountains, and are at present only known from the ranges adjoining the Columbia on the east. They are found on both sides of the Beaver-foot Range, and good and easily accessible sections, close to the railway, may be found in the bed of a small stream which joins the Wapta from the north, about half way between Palliser and Golden City. Most of the graptolites mentioned in the sequel were collected at this point.

The fossils obtained from this formation consist entirely of graptolites, and the collection made has been submitted for examination to Professor Lapworth, who contributes the following notes in regard to it:—

Fossils.

"There are few species in this collection, but the forms are generally

fairly well preserved, and the fauna represented is a distinctly typical one. The following are the species I have identified:—

(*a*) Family DICHOGRAPTIDÆ.

(1) *Didymograptus*, sp. nov., allied to *Didymograptus enodus*, Lapworth, from the Llandeilo beds of Aberiddy Bay, South Wales. (See Quart. Journ. Geol. Society, 1875, plate 35, figs. 1a 1b.)

(*b*) Family GLOSSOGRAPTIDÆ.

(2) *Glossograptus ciliatus*, Emmons.
(3) " *spinulosus*, Hall sp.

(*c*) Family DIPLOGRAPTIDÆ.

(4) *Cryptograptus tricornis*, Carr. sp.
(=*C. marcidus*, Hall sp.)
(4) *Diplograptus angustifolius*, Hall.
(6) " *rugosus*, Emmons.
(7) *Climacograptus cœlatus*, Lapworth.

There are also a few other forms, doubtful species of *Phyllograptus* or *Lasiograptus*, etc.

"The fact that these graptolites have been obtained from the distant region of the Rocky Mountains gives them an especial interest, as few graptolites have hitherto been noticed from that region. The only notice of graptolites from the Western States known to me is that given by Dr. Chas. White in Vol. IV. (Palæontology) of the Report of the Geological Survey of the 100th Meridian. Four forms are described by him (*loc. cit.* pp. 9-10 *et seq.*) as having been obtained from some beds of partially metamorphosed shale, five miles north of Belmons, Nevada. No fossils were found associated with them that might assist in the determination of their exact age, and they were provisionally referred to the geological date of the Utica slate of New York State.

"These graptolites from the Kicking Horse (Wapta) Pass under notice may also be referred to the age of the Utica slate, or at any rate to the Trenton-Utica fauna of the United States and Canada. The association of forms is just such as occurs in the Llandeilo (lower and middle) of Britain, and some of the forms are common to both sides of the Atlantic. The geological range and geographical localities of the forms enumerated above are shown in the table on the following page.

"It is curious that none of the family of the Dicranograptidæ (*Dicranograptus* and *Dicellograptus*) are represented in this little collection. It is just possible that it may, therefore, be somewhat older than the

typical Norman's Kill beds, where the Dicranograptidæ are exceedingly abundant. Neither have we any of the peculiar genera of the Leptograptidæ (*Cœnograptus* and *Leptograptus*, etc.) so prevalent in the Norman's Kill horizon everywhere. Thus it is by no means unlikely, judging from the evidence at present at our disposal, that the fauna of the shales of the Kicking Horse (Wapta) Pass come from strata answering broadly to the British Lower Llandeilo. They are distinctly newer than the Point Levis beds, and belong to the second Ordovician fauna, but in all probability to the oldest zones of that fauna.

"Table showing distribution (geographical) of the graptolitic species of the Kicking Horse (Wapta) Pass, B. C."

	America.		Britain.			
	Norman's Kiln, N. Y.	Marsouin River and Griffin Cove, Can.	Lower Llandeilo of Aberiddy Bay. S. Wales.	Llandeilo of Shropshire. Shropshire.	Glenkiln shales of S. Scotland. Scotland.	r—representative forms; not certainly identified with typical species.
1 Didymograptus enodus, *Lapworth*	—	—	•	•	—	
2 Glossograptus ciliatus, *Emmons*	•	•	•	•	•	
3 " spinulosus, *Hall*	•	—	—	—	•	
4 Cryptograptus tricornis, *Carruthers*	•	•	•	•	•	
5 Diplograptus angustifolius, *Hall*	•	•	•r	•r	•r	
6 " rugosus, *Emmons*	•	•	—	•	•	
7 Climacograptus cœlatus, *Lapworth*	.....	•	•	•	•	

The Castle Mountain Group.

Castle Mountain group. The Castle Mountain group is the most widely distributed series in this part of the range, and is the only one which is found on both sides of the great break west of the Saw-back Range. In the eastern ranges it is overlaid by the Intermediate limestone, and in the west, along the Columbia, by the Graptolitic shales. **Thickness.** It has a known minimum thickness of 7700 feet, but as the whole series was never seen in one section, and none of the horizons could be traced for any distance across the folds, it is highly probable that this estimate is too small, and that its total volume approaches 10,000 feet.

Composition of rocks. The Castle Mountain group is essentially a limestone formation, and consists of ordinary and magnesian limestones, together with every

gradation between them and calcareous shales and schists. Its mode of stratification, like its composition, and dependent upon it, is very variable, and massive beds of hard limestone are often replaced in the course of a few miles, by cleavable calc-schists and soft shales. The beds are more persistent along the strike than in a transverse direction, and the harder bands project as longitudinal ridges, often of great length, separated by valleys, which mark the position of the softer varieties.

Stratification.

Amongst the most important rock species of this formation, are the dolomites of the Castle Mountain range and other places. These occur in heavy beds, often several feet in thickness, and weather into steep, massive-looking cliffs. They are usually compact, or moderately crystalline, in texture, but numerous fragments, observed along the eastern edge of the Otter-tail Range, resemble Archæan limestones in their coarseness. It is possible, however, that these may be derived from veins, as they were not seen *in situ*. The dolomites on a fresh fracture have a greyish or banded appearance, but weathered surfaces are always more or less rusty. The deep ferruginous coloration of irregular patches, which is observable in some of the sections, is probably due to local influences. A variety of this rock, seen near the base of the formation at Emerald Lake, has a peculiar cavernous structure. The cavities are small, are partly refilled, and run in lines parallel with the bedding.

Dolomites.

A large proportion of the rocks of the Castle Mountain group, consist of mixtures, in various proportions, of dolomites and limestones. The ribanded limestones, found in the ranges west of the summit, are of this character, and are often regularly and beautifully striped with different colours. In some instances, where this rock is much weathered, the dolomitic layers project, as yellowish ribs, above the greyish calcareous bands.

Ribanded limestone.

In the calcareous variety occuring at the gap of the Bow, and along the eastern part of the Devil's Lake valley, the dolomitic and other impurites, have segregated together, and are arranged in irregular broken lines, parallel with the bedding.

In the Wapta Valley, west of Field, the limestones and dolomites are associated with a great series of greenish calc-schists, and greenish and reddish shales and slates. These schistose rocks often show green, glossy surfaces, but are never very highly altered, and hold few secondary minerals. They are usually soft, are highly calcareous, and are traversed by a set of cleavage planes, dipping at a high angle and running parallel to the general direction of the chain. A second set of cleavage planes, striking nearly at right angles to the first, is developed in some localities, but is of less importance.

Limestones associated with argillittes.

Cleavage.

The greenish variety comes to the surface in the bottoms of the wide longitudinal valleys of the Otter-tail and Beaver-foot, and is replaced in the neighbouring ridges by the more indurated greyish and reddish shales, slates, and limestones.

A series of four specimens from this formation, representing stages in the transition from heavily bedded dolomites to cleaved dolomitic slates and schists, was examined by Mr. F. D. Adams, in order to ascertain if the structural changes are due to original differences in composition, or are simply indicative of varying degrees of mechanical alteration. The results of his examination are given in the following notes:—

Analyses by Mr. Adams.

I. From Mount Stephen.—A bluish-gray dolomite, with indistinct lines of banding.

Insoluble residue	1·069	per cent.
Carbonates	98·931	"
	100·000	

The insoluble, before ignition, was greyish-black in colour. After ignition, it was white, with a faint reddish tinge, and seemed to consist principally of quartz. The dark colour previous to ignition was due to organic matter.

II. From Van Horne Mountains.—A very finely laminated brown dolomitic argillite. Shows lines of bedding transverse to the plane of lamination.

Insoluble residue	82·719	per cent.
Carbonates	17·281	"
	100·000	

The insoluble residue, which, before ignition, was of a faint brownish colour, after ignition was of a light brownish-grey colour. It was found to be composed of silica and alumina, with a small quantity of ferric oxide, lime and magnesia, and is therefore argillaceous matter. The acid solution was found to contain, in addition to lime and magnesia, a little ferric oxide and alumina.

III. From Otter Tail Valley.—A rock composed of more or less lenticular shaped pieces of a bluish dolomite, separated by thin partings of argillaceous matter.

Insoluble residue	42·524	per cent.
Carbonates	57·476	"
	100·000	

"The insoluble, which, before ignition, was of a rather dark bluish-grey colour, and which after ignition was white, was composed of silica, alumina and a little lime. It is therefore also argillaceous matter, but probably contains a small admixture of quartzose material. The acid solution contained, in addition to lime and magnesia, a little alumina and ferric oxide.

"IV. From Mount Hunter.—Resembles No. III., but is of a buff colour, and has a much better developed schistose structure.

Insoluble matter	43·069	per cent.
Carbonates	56·931	"
	100·000	

"The insoluble residue had before ignition a faint, brownish tint, and after ignition was of a light-brown colour. It was very gritty, and probably consisted, for the most part, of quartzose material. The acid solution contained proportionately more lime and less magnesia, than in the case of any of the previous specimens, showing that the rock is an impure magnesian limestone rather than an impure dolomite. The acid solution also contained a little alumina and ferric oxide, as before.

"In determining the amount of insoluble residue present in those rocks the carbonates were removed by means of dilute nitric acid. The small quantities of water and organic matter present in the rocks are here included with the carbonates, which were determined by difference.

"These four specimens are believed to represent, pretty closely, the several series from which they were taken, and their examination was undertaken with a view to ascertaining whether Nos. 2, 3 and 4 could have been produced from No. 1, by simple process of diagenesis. The results given above show that this is not possible, No. 1 being a nearly pure dolomite, while, Nos. 2, 3 and 4, in addition to numerous minor differences, contain on an average more than 50 per cent. of argillaceous or silicious matter. It must, however, be mentioned that No. 1 does contain small beds of rock, similar in composition to Nos. 2, 3 and 4, a small fragment of shaly rock, from one of these beds, was found to be an argillaceous dolomite, resembling, in a general way, No. 2 and 3. No. 5 also forms small beds in a dolomite, equivalent to No. 1." Dolomites and dolomitic shales.

In addition to the rock varieties of this group, already mentioned, a hard limestone conglomerate appears, towards the top of the formation in the Sawback Range and other places, and beds showing a peculiar oolitic structure, are also common in some localities. Mr. Adams furnishes the following description of a specimen of this rock from near Hector Station, Hector Pass. Limestone conglomerate. Oolitic beds.

Description of oolite.

"A sort of oolite, consisting of small, globular concretions of a bluish-black colour, imbedded in a dull, yellowish ground-mass. The concretions are about one millimetre in diameter, and form about half the volume of the rock. When a section of the rock is examined under the microscope, each concretion is seen to be composed of numerous elongated individuals of calcite, radiating from its centre to its circumference. Each concretion thus forms a well defined spherulite, which, between crossed nichols, shows a more or less perfect black cross, whose arms are parallel to the vibration planes of the nichols. They show no concentric structure, but are well defined against the ground-mass, which is very fine-grained and contains much argillaceous matter. By transmitted light the concretions are of a very light brownish colour. When separated from the ground-mass and treated with cold, dilute hydrochloric acid, they disolve readily, leaving some flocculent (argillaceous ?) matter, to which their light brownish colour, by transmitted light, is probably due. The acid solution is found to contain much lime, and a small quantity of magnesia, but no ferric oxide. The rock itself, even in fragments, dissolves readily in cold, dilute, hydrochloric acid, but leaves a large amount of insoluble, apparently argillaceous, matter. The acid solution contains much lime, with a smaller amount of magnesia and a little alumina and ferric oxide, showing that the rock is an impure magnesious limestone."

Beds dolomitic below and calcareous above.

Section in Castle Mountain.

The sequence and relative importance of the various members of this group, differ widely in every section, but as a rule, the beds are more dolomitic and more heavily bedded below, and become more shaly and calcareous above. In the Castle Mountain section, the series commences with a thin band of shaly, limestone, above which comes 1500 feet of massive dolomites, forming the steep cliff face of the range. The massive dolomites are overlaid by some yellowish, compact impure dolomites, and these by 300 feet of reddish shales, above which comes several hundred feet of shaly, magnesian limestones, forming the top of the mountain. Mount Stephen shows a section of about 5000 feet, consisting mainly of heavy dolomites, but holding shaly bands at intervals. One of these, occurring at the base of the formation, and another about 2000 feet higher up, are rich in trilobites. In the Sawback Range, the base of the formation is faulted off, but the part present shows several thousand feet of heavy limestones, mainly dolomitic, interstratified with some shaly bands, and passing upwards into more flaggy beds. At the summit of Johnson Creek, the upper part of this section contains some schistose beds closely resembling those of the Otter-tail Valley. At the gap of the Bow, and of Devil's Lake valley, the base is again faulted off, and the limestones and dolomites in sight represent the upper part of the

Schistose beds at summit of Johnson Creek.

formation. At the former locality, the limestones are associated in one place with some schistose beds. In the Beaver-foot range, the highest beds of the series occur, and consist of impure shales and shaly limestone, passing downwards into more altered beds. The exact position in the series of the schists, shales, and limestones of the Van Horne and Hunter ranges, has not been determined. They are unfossiliferous, and are separated from known horizons by disturbed zones, across which it is impossible to trace individual beds or even a series of beds.

The beds of the Castle Mountain group are found at the gap of the Bow, where they form the outer range, overlooking the plains, and extend from there, in a gradually widening band, north to the Devil's Lake valley and beyond. They are next met with, going west, in the Sawback range, and still further on in the Castle Mountain range. After crossing the Bow River anticlinal, which brings up lower rocks, they are again met with in the watershed range, and then cover all the surface as far as the Columbia, with the exception of the central part of the Beaver-foot range, and a small area in the valley of the Wapta, between Wapta Lake and Field. **Distribution of Castle Mountain group.**

The Castle Mountain group extends from the Cambrian up into the Cambro-Silurian, and seems to have approximately the same range as the Pogonip limestone of Clarence King's Middle Nevada section.

A hasty examination of some of the fossils obtained from it enabled Mr. Whiteaves to recognize species belonging to three distinct horizons. Such Lower Cambrian forms as *Paradoxides*, &c., were found near its base, and about 2000 feet higher up such Middle Cambrian genera as *Olenoides* and *Doropyge*, with two species of *Bathyourus*, while the upper beds yielded *Raphistoma rotuliformis* and an *Asaphus*, and are, therefore, probably Cambro-Silurian (*Ordovician*). **Fossils.**

Bow River Series.

The Bow River group forms the basal member of the section in this part of the mountains, and, as developed along the line of railway, consists mainly of a great series of dark-coloured argillites, associated with some sandstones, quartzites and conglomerates. The base is not seen, but the part exposed has an estimated thickness of 10,000 feet. **Bow River group.** **Thickness.**

The argillites are usually dark-greyish in colour, but become greenish and purplish in places, are very impure, and frequently grade into flaggy sandstones, which are often slightly calcareous. The small quantity of lime present is due doubtless, in most cases to a decomposition of the felspathic constituents of the rock. They are hardened and occasionally cleaved, and scales of mica are often developed along **Argillites.**

divisional planes, but on the whole show comparatively little alteration for beds of this age.

Conglomerates. The conglomerates are described in the following terms by Dr. Dawson (Annual Report, 1885, p. 159 B) :—"The conglomerates above alluded to were seen for the most part in connection with the Cambrian anticlinal of the upper part of the Bow Valley. They are characterized by pebbles of milky or semi-transparent quartz, together with pieces similar in size of fresh-looking, whitish felspar, and the matrix contains abundance of pale mica. These constituents have evidently been derived from some not far distant exposures of coarse granitic or gneissic rock. Fragments are found of dark, lustrous schist. Rocks of the character of those largely developed on Shuswap Lake and in the Gold range would afford such material."

The conglomerates characterize more especially the top of the formation, and occur in thick, massive-looking bands, alternating with quartzites and shales. They are usually firmly cemented into a hard, unyielding rock, but are also met with in a little consolidated and crumbling condition.

Quartzites. The quartzites, like the conglomerates, are mostly found in the upper part of the formation, and sometimes, as in Cathedral Mountain, replace the latter altogether. They are largely developed in the watershed range between Eldon and Laggan, where they rise into high foot-hills in front of the main limestone peaks.

Distribution of Bow River group. The Bow River series occupies the wide longitudinal valley east of the watershed range, and is met with all along the line of railway between Silver City and Stephen. A little east of this latter place it is carried below the surface by a synclinal fold, but appears again about a mile west of Wapta Lake, and then gradually rises in Cathedral Mountain, until it meets the fault, which runs in a northwesterly direction between Mount Stephen and Cathedral Mountain, by which it is brought almost down to the surface of the valley, and is soon afterwards buried by a westerly dip. It is possible that some of the schistose rocks of the Otter-tail and Beaver-foot valleys, which have been referred to the Castle Mountain group, may belong to this series.

Fossils. The only fossils obtained from this formation were collected by Dr. G. M. Dawson at the summit of the Vermilion Pass in 1884, and consist of a couple of trilobitic impressions, one of which has been identified by Prof. C. D. Walcott as *Olenellus Gilberti*, a characteristic Middle Cambrian fossil.

Structural Features.

The Rocky Mountains, in the latitude of the present line of section, are divided by radical differences in structure into two distinct geological provinces, the line of division being nearly coincident with the western base of the Sawback range. The region east of this line has been broken by a number of parallel or nearly parallel longitudinal fractures into a series of oblong orographic blocks, and these tilted and shoved one over the other into the form of a westerly-dipping compound monocline. In the section examined there are seven principal faults, besides some of minor importance, and six well-defined blocks, the latter resting on one another in regular succession from west to east. The thrust producing these crust movements and dislocations came from the west, and must have been highly energetic in its action, as some of the breaks are of huge proportions, and are accompanied by displacements of many thousands of feet. The faulted region is now about twenty-five miles wide, but a rough estimate places its original width at over fifty miles, the difference indicating the amount of compression it has suffered. Overturned folds were observed along the courses of some of the faults, but they are usually small, and are of minor importance as a structural feature, and the great earth rents of the district seem to have been produced without much preliminary bending. The tilted blocks form a series of more or less parallel ridges running lengthwise with the chain, but the intervening depressions, unlike those of the Great Basin, where the structure is somewhat similar, are true valleys of erosion, and although their direction is determined by the course of the fault, are due to the unequal hardness of the formations. In one of these valleys the fault is invariably found along the base of the cliff like part of the ridge bounding it on the west—the cliff being formed by the truncated edges of one or more of the older formations,—while the greater part of the valley is dug out of the inclined Carboniferous or Cretaceous shales which always cover the western slopes of the ridges, and mark the beginning of a repetition of the formations.

Two provinces. Faults. Thrust from the west. Compression of faulted region. Overturned folds. Parallel ridges. Valleys of erosion.

A section through a typical ridge, starting from the west, shows first Cretaceous shales faulted under one of the older formations, and underlaid by the Banff shales and limestones. The Banff limestones usually form the central portion of the ridge, and rise into the higher peaks. They are underlain by the Intermediate limestone, followed below by the beds of the Castle Mountain group. The latter is broken through and faulted up over the Cretaceous shales, and the same succession is again repeated.

Typical section.

Varying throws

The faults have, however, varying throws, and all the beds from the Upper Banff shales to the Castle Mountain group inclusively, are brought in different places in contact with the Cretaceous shales, which here form the top of the series.

Type of structure unusual.

The type of mountain structure described above is somewhat unusual, and has not, so far as I am aware, been noticed as a prominent feature in any of the reports treating of the disturbed belt of the western part of the continent. The Basin range structure, which produces a similar system of parallel ridges, is caused by normal faulting, and the intervening valleys are not due to erosion but to a sinking of the beds on the downthrow side of the fault.

Similar structure in Appalachian region.

In the southern extenston of the Appalachian region, however, the valley of East Tennessee presents an almost identical structure, and Professor J. M. Safford's interesting section across this valley might almost be taken for an illustration of the structure of this part of the Rocky Mountains. The close parallelism between the structures of the two regions may be seen by comparing the following description with what has been written:—"The length of the section is fifty-two miles. Eight great faults are crossed. It is to be observed that no great flexures occur. This is the most crowded part of the valley. The incipient folds were split open longitudinally, and the south-eastern side of each heaved up and over the north-western. The older formation is on the south-eastern side of a fault. In passing from one fault in a south-easterly direction to another, the successive formations are met with in ascending order, until the second fault is reached; passing this, an older formation occurs again, to be followed, as before, by newer ones. The formations are thus arranged by the faults into successive series, the series being much alike, in fact, to a great extent, repetitions of the same thing. In the section there are eight of these series between Walden's Ridge and Chilhowee Mountain."*

The recent investigations in the Scotch Highlands have also shown that the beds there are affected by a similar system of faulting.†

Structure of western part of chain different.

In the western part of the chain, between the Sawback range and the Columbia, the structure is entirely changed; no reversed faults have yet been recognized there, and ordinary and overturned folds play the most important role. The greater part of this district has also been subjected to regional metamorphism, and all the beds, except the purer limestones, are in a more or less altered condition.

The constituent formations of the two regions, as well as the structure, are very dissimilar, and some of the formations, when traced westwards, become greatly changed.

* Geology of Tennessee, page 190.
† Nature, vol. xxxi., page 29.

The formations found in the eastern province consist, in descending order, of the Cretaceous shales, the Banff limestones and shales of Devono-Carboniferous age, the Intermediate limestone of Devonian age, and part of the Castle Mountain group of Middle and Lower Cambrian age, measuring altogether about 18,000 feet. The whole series, notwithstanding the gaps in the sequence, is conformable throughout. The Castle Mountain group, in its occurrence along the eastern edge of the mountains, contains no beds newer than the Cambrian, and is overlain directly by the Devonian, but in its western extension appears to pass up gradually into the Cambro-Silurian. Formations in eastern province.

In the western province the Cretaceous shales, the Banff limestone and the Intermediate Limestone are wanting, and the highest beds belong to the Silurian—a formation unknown in the eastern district. The Silurian or Halysites beds are followed conformably, in descending order, by the graptolitic shales of Utica-Trenton age, the Castle Mountain group, and the Bow River group of Middle and Lower Cambrian age. The section here has a thickness of 23,000 feet, the greater part of which is Cambrian. Formations in western province.

The dominant structural features of the eastern district, as stated before, are due to a series of gigantic thrust faults, which have carried the older formations forward, and placed them in a number of places above the highest beds of the series. One of the largest and most important of these occurs along the eastern base of the chain, and brings the Cambrian limestones of the Castle Mountain group over the Cretaceous of the foot-hills. This fault has a vertical displacement of more than 15,000 feet, and an estimated horizontal displacement of the Cambrian beds of about seven miles in an easterly section. The actually observed overlap of the older beds as shown on section D–C amounts to nearly two miles. The angle of inclination of its plane to the horizon is very low, and in consequence of this its outcrop follows a very sinuous line along the base of the mountains, and acts exactly like the line of contact of two nearly horizontal formations. Dominant features. Great fault at base of range.

The best places for examining this fault are at the gaps of the Bow and of the south fork of Ghost River. At the former place the Cretaceous shales form the floor of the bay which the Bow has cut in the eastern wall of the range, and rise to a considerable height in the surrounding slopes. Their line of contact with the massive grey limestones of the overlying Castle Mountain group, is well seen near the entrance to the gap, in the hills to the north. The fault plane here is nearly horizontal, and the two formations, viewed from the valley, appear to succeed one another conformably. The line of junction can be traced westward for about half a mile, but towards the upper part of the gap becomes concealed, and soon afterwards the

Cretaceous rocks bend down and are carried below the surface by a westerly dip. This undulation in the fault plane must indicate a period of disturbance subsequent to that in which the main faulting was produced.

Undulation in fault plane.

The Cretaceous shales are bent sharply towards the east in a number of places, but with this exception have suffered little by the sliding of the limestone over them, and their comparatively undisturbed condition seems hardly compatible with the extreme faulting which was necessary to bring them into their present inferior position. They are, however, very soft, and doubtless owe their immunity to this fact. It is otherwise with the overlying limestones, which have been strongly corrugated in many places, and are often whitened and cracked in the vicinity of the fault plane, the cracks having been subsequently filled with calc-spar. Enclosed argillaceous beds have also been turned into schists, and the banded appearance of much of the limestone is, no doubt, due to the shearing caused by the thrust.

Shales little disturbed.

Limestones much altered.

At the gap of the south fork of Ghost River, where the fault was next examined, the Cretaceous shales, after dipping below the surface, rise again about a mile farther up the valley, and remain exposed for some distance before they finally disappear. The Castle Mountain group here is reduced to a mere tongue, only a few hundred feet thick, separating the Intermediate limestone from the Cretaceous, but, as it thickens out greatly when traced westwards, its faulted character is very evident. The section at this point has a further interest in the fact that a number of Benton fossils were found in the shales directly under the limestone, while a couple of miles north, along the strike of the beds, the overlying limestone yielded Cambrian fossils.

Character of fault at south fork of Ghost River.

Underlying shales hold Benton fossils.

The plane of the fault dips to the north after passing the south fork of Ghost River, and at the gap of the Devil's Lake valley the shales have disappeared, and the section shows only the overlying limestones.

The small area of Cretaceous shales observed by Dr. Dawson in the bottom of the valley of the Elbow River, about two miles west of the edge of the Palæozoic rocks, is probably to be accounted for by the continuation of the same great thrust fault to the south of the Bow, repeating the conditions described on the south fork of Ghost River.

Going up the Devil's Lake valley, along which the main section is measured, the flat lying beds of the Castle Mountain group, overlain in the higher peaks by the Intermediate limestone, are observed to occupy both sides of the valley for some miles. Farther up they dip to the west, and are overlain successively by the Banff limestone and the Cretaceous shales, and then the sequence is again broken, and the latter are faulted for a second time under the older beds. This fault has a steeper hade, and consequently a straighter outcrop than the one

Second fault.

described before, and its throw is also much less, as it nowhere exposes beds lower than the Banff limestone. It follows a large straight valley running lengthwise through the whole extent of the Fairholme Mountains, and has also been traced north of the Devil's Lake valley for some miles. It runs about N. 25° W.

The distribution of the Cretaceous shales along the eastern side of this fault is somewhat peculiar, as they have been preserved only in patches at the summits along the longitudinal valley which accompanies the fault, and have been removed from all the lower parts by denudation. They are consequently not seen at the low elevations at which deep transverse valleys, like those of the Devil's Head and Bow, cross the line of fault. Distribution of shales.

About a mile farther west, still going up the Devil's Head valley, the beds in the mountains to the north suddenly become violently folded, indicating that a third line of disturbance is reached. The folding here is not accompanied by much faulting, and is caused by the disturbance of the beds in the prolongation of a faulted line. Traced to the north, however, it soon develops into a well-defined fault, and in a few miles has a throw of several thousand feet, and brings the Lower Banff limestone up against the Upper Banff shales. The line of this fault strikes more to the west than the preceding one, and if continued south would join the latter a short distance south of the valley. Beds much disturbed.

A fourth fault crosses the valley about two miles east of the west end of Devil's Lake, and as it brings the Intermediate limestone over the Banff, must have a throw of about 6000 feet. This fault, like the one last referred to, dies out when followed southwards, and near the Bow is represented by an anticlinal fold. Traced northwards into the Palliser Range, newer beds are introduced in consequence of the increased elevation, and in place of the Intermediate limestone overlying the Banff series, as in the valley of Devil's Lake, the Banff series overlies the Cretaceous shales. A comparison of section G, in the accompanying series of sections, with the corresponding part of the general section, will make this clear. Fourth fault.

West of this faulted region comes the Cascade trough, a wide depression based mainly on Cretaceous shales. The shales here are coal-bearing, and on this account the basin was examined with some care by Dr. Dawson during the course of his exploration, and a detailed account published in the Annual Report for 1885. (See Part B, p. 126.) The synclinal fold described by him is not evident along the line of the general section, but is well shown a few miles farther south, in the transverse ridges between the Bow and the Kananaskis. The attitude of the beds here is illustrated in the two sections H and K. The limestones on the west have been broken and shoved forcibly over the Cascade trough Synclinal fold.

Cretaceous shales, and in their forward movement have folded the latter and even overturned them in places. The axis of this fold gradually approaches the western boundary of the basin to the northward, and must become nearly coincident with the eastern edge of the limestone in the vicinity of the entrance to the White Man's Pass. North of this, it is highly probable that, for some distance at least, only the eastern limb of the fold is present, but the fragmentary character of the sections exposed in this part of the valley made it impossible to prove this satisfactorily.

Only eastern limb of fold present.

Length of fault.

The fault along the western edge of this trough has been traced from the Kananaskis River, in a direction about N. 35° W., for about forty miles, and must also extend southwards for some considerable distance, as it is found there in full force. It appears to attain its maximum throw nearly opposite Canmore, where it cuts through the Intermediate limestone, the whole Banff series, and at least 4000 feet of Cretaceous, indicating altogether a displacement of over 10,000 feet. To the north the throw rapidly diminishes, and the Intermediate limestone, followed by the various members of the Banff series, are successively buried by the Cretaceous shales east of the fault. The gradual disappearance of these formations is plainly shown in the naked easterly slopes of Cascade Mountain, and in the same range the intimate relations existing between ranges and faults may also be observed. This range is built of limestone beds dipping westwards, and presenting their truncated edges to the east, and where cut by the Bow Valley has an elevation of over 5000 feet. It descends to the north in close connection with the decrease in the throw of the fault, and, after the latter passes into an anticlinal fold, becomes reduced to a low, rounded ridge.

Extent of throw.

Connection between ranges and faults.

Limestones west of fault.

The limestones west of the fault are often bent by their pressure against the beds on the eastern side into a succession of sharp folds, and are occasionally completely overturned. They also show disturbances in the altered and cracked appearance of the strata in the immediate vicinity of the faulted line.

Smaller faults.

In addition to the principal dislocation along the western edge of the Cascade basin, a couple of smaller faults are also known to occur on the eastern side, but were not accurately determined. They are instrumental in repeating some of the upper beds of the Banff series, but are otherwise of little structural importance.

Fault east of Vermilion Lake Range.

West of the Cascade basin and range, and running along the eastern base of the Vermilion Lake range and Terrace Mountain, is a second great fault, almost equal in importance to that just described. The Cretaceous is absent here, so far as known, and the Upper Banff limestones and overlying quartzites and shales, which now form the top of

the series, are folded back on the eastern side of the fault, and are overlaid by the older Intermediate limestone. The thermal springs previously mentioned are situated in close proximity to the line of this fault.

A third fault occurs east of the Sawback Range, and has displaced the beds to a greater extent than any met with west of the gap, as it cuts through the Banff series and the Intermediate limestone, and exposes about 5000 feet of the Castle Mountain group. The fracture here is either compound or encloses fragments of both the Intermediate and the Banff limestones, which have been sliced off and carried to the surface. Incomplete sections of both these formations are found along the line of fault between the Castle Mountain group and the Upper Banff shales, and in one case the beds of the latter, folded closely together and thrown into an upright position, form a series of sharp peaks running parallel with the range. The high hade of this fault, and close parallelism of the beds both above and below it, are somewhat remarkable, but are features not infrequently met with in the reversed faults of highly disturbed regions. In most of the faults already noted the hade corresponds very closely with the dip of the overlying beds, and a steeper tilting of the strata enclosing the fault plane would cause them to assume much the same appearance. **Fault east of Sawback Range.** **Steep hade.**

A fourth line of fracture and disturbance—counting from the Cascade basin—but the eighth from the gap, and the last of the series, occurs at the eastern base of the Castle Mountain range, and forms the dividing line between the two geological provinces. The faults and foldings along this line are as yet imperfectly understood, and will require much additional examination. They are extremely complicated, and a glance at the accompanying section will show their rapid change in character along the strike, and the little correspondence existing between neighboring parallel sections. **Fault east of Castle Mountain.**

The general section crosses the Bow Valley opposite Pilot Mountain, and is continued on to the Bow River anticlinal, and then jogged northwards along the strike to the entrance to the Hector Pass. In this section the beds are bent into a synclinal attitude, and the formations represented in the Sawback Range, after dipping below the Bow Valley, are repeated on the other side in Pilot Mountain, and their easterly dip is then maintained until the beds of the Bow River group are exposed. Disturbed lines, probably accompanied with some faulting, cross this section near the centre of the Bow Valley, and again west of Pilot Mountain near the point of contact of the Bow River and Castle Mountain groups. **Direction of general section.** **Disturbed lines.**

Section M—L crosses the disturbed belt about fourteen miles further n ear the summit of Johnson Creek, and is broken by two large

Section near summit of Johnson Creek.

faults. The most easterly of these places the Castle Mountain group over the Banff series, and brings beds together which are normally separated by over 12,000 feet of intervening strata, and the one to the west lifts the beds of the Bow River group over the upper part of the Castle Mountain group. The latter group, in its recurrence here, is continued upwards into beds holding Cambro-Silurian fossils, while farther east it is Cambrian throughout, and is overlain by the Devonian.

Section north of Baker's Creek.

Section O—N, sketched north of Baker Creek, about eight miles farther along the strike, shows a great thrust fault, something like that occurring along the eastern edge of the mountains. The beds here seem to have been first completely overturned, and then the upper limb of the anticlinal torn from the lower and slidden along it for miles, as the beds brought in contact indicate a vertical displacement of over 10,000 feet. The disturbance east of this fault has been intense, and has produced much folding and alteration. In one case, about a mile north of the section, some of the Bow River group conglomerate was found interbedded with the Banff limestone, either folded or faulted in, in some way not easily understood. This section shows the relations of the formations, north of the valley of Baker Creek, but going south the fault plane must either bend suddenly downwards or is let down by a cross fault, as the southern bank of this valley shows only the beds of the Castle Mountain group. This uneveness of the fault plane probably indicates a second period of disturbance.

Great Disturbance.

West of this line of disturbance the structure of the mountains changes completely, and reversed faults and westerly dips, hitherto all important, cease to be the prevailing features. The Castle Mountain range—the first range in the western geological division—has the form of a gentle syncline, and is built of the shales, quartzites and conglomerates of the Bow River group, overlain by the massive dolomites and the limestones and shales of the Castle Mountain group. This syncline is followed by a great anticlinal fold, which brings up the lowest beds found in the range. The seemingly prodigious thickness of the Bow River group in this anticlinal, as shown in sections M—L and O—N, is probably due, to some extent at least, to repetitions caused by subsidiary foldings. Farther west in the watershed range the beds bend under a second moderately flat synclinal, and are then displaced by a steep fault. These folds all strike about N. 35° W. The dips are shown in the accompanying section and need not be described. The fault mentioned above passes between Mount Stephen and Cathedral Mountain, and on the opposite side of the valley runs through the eastern shoulder of Mount Field. It has a hade of 75° and a downthrow to the west of about 3000 feet.

Synclinal and anticlinal folds.

Bow River group.

The beds of the Bow River group, almost buried by this fault, are

arched up again by a second anticlinal, and are then exposed for some distance along the base of Mount Stephen, but disappear finally about a mile east of Field. They are overlain and followed round the anticlinal by the dolomites of the Castle Mountain group, of which the upper and greater part of the mountain consists.

West of Mount Stephen, in Mount Dennis, the beds become violently flexed, and at the same time the dolomites are replaced by cleaved dolomitic argillites. These beds have been classed with the Castle Mountain group, but the reference is not altogether free from doubt. They are sharply separated from known horizons by the disturbed belt noted above, are destitute of determinable fossils, and are also much more argillaceous than the typical Castle Mountain dolomites, but closely resemble in this respect the shaly bands which occur all through that formation, but which are especially characteristic of its upper part. To establish their relationship satisfactorily, however, it would be necessary to measure a connecting section in a less disturbed district. Mount Dennis.

These beds are cut by a series of small calcite or quartzite veins, which run nearly parallel with the bedding, and are often metalliferous. They are found in the valley of the Otter-tail, where they consist of soft, greenish, imperfectly schistose beds, dipping to the west at a high angle, and in the Van Horne and Otter-tail ranges, where they are characterized by lower dips and are associated with reddish slates and limestones. Both these ranges are traversed by a longitudinal system of nearly vertical cleavage planes, and also by a second less conspicuous set running nearly at right angles to the first.

Mount Hunter, west of the Van Horne Mountains, owes its origin to a band of heavy bedded limestones, which here occurs in this series, and has been bent almost at right angles in the peculiar manner shown in the section. West of this point the prevailing dips are to the east. The valleys of the Wapta and Beaver-foot are underlain by soft, greenish schists, almost exactly the same as those found in the valley of the Otter-tail, but dipping in the opposite direction. In the Beaver-foot Range the Castle Mountain group is overlain by newer beds, and the whole series along the section cut by the Wapta River is bent into a synclinal attitude and overturned to the west. South along the range this syncline flattens out, and opposite Palliser the upper beds are only slightly bent. There is reason to suspect, however, that the beds here are displaced by a fault. West of the Beaver-foot range,—the most westerly range of the chain—in the Columbia valley, the beds of the Castle Mountain group are represented by impure shaly limestones, passing into calcareous and often somewhat altered argillites. These beds have a westerly dip, and are sharply corrugated in places. They are cut by a set of small calc-spar veins, which have usually nearly the Mount Hunter.

same inclinations as the strata, and are crumpled in a similar manner with the beds.

Conclusion. The portion of the Rocky Mountains examined in the construction of the accompanying section is thus characterized in its eastern part by a series of great fractures and thrust faults, in the centre by broad, sweeping folds, and in the west by folding and crumpling, accompanied by the development of cleavage-planes and a limited amount of metamorphism. Among its other more important features, may also be noted the absence of recognizable unconformities, the absence of any of the older crystalline schists, the relatively smaller amount of disturbance in the central parts of the range than towards the edges, the want of similarity in the sequence of the formations east and west of the axis, and the marked preponderance of calcareous beds between the Middle Cambrian and the Cretaceous.

NOTES ON ECONOMIC MINERALS.

The following notes are partly reprinted from the Preliminary Report given to the Director on my return last autumn, and since published in the Report of the Minister of the Interior.

The section of the mountains in the vicinity of the railway contains a variety of mineral deposits, and has every indication of becoming an important mining region. The Cretaceous beds of the Cascade trough hold a number of seams of excellent coal, while farther west the Cambrian and Cambro-Silurian limestones and schists, which cover most of the country between Silver City and the Columbia, are almost everywhere metalliferous, and few mountains have been prospected in this district which have not yielded ores of some kind.

In the past season, with the exception of some work in the Otter-tail valley and in the Banff coal mines, little mining of any importance has been attempted, but prospecting has been actively and successfully engaged in, and a number of valuable discoveries are reported.

In the Silver City district, mining at present is at a standstill, and, beyond prospecting, nothing is being done.

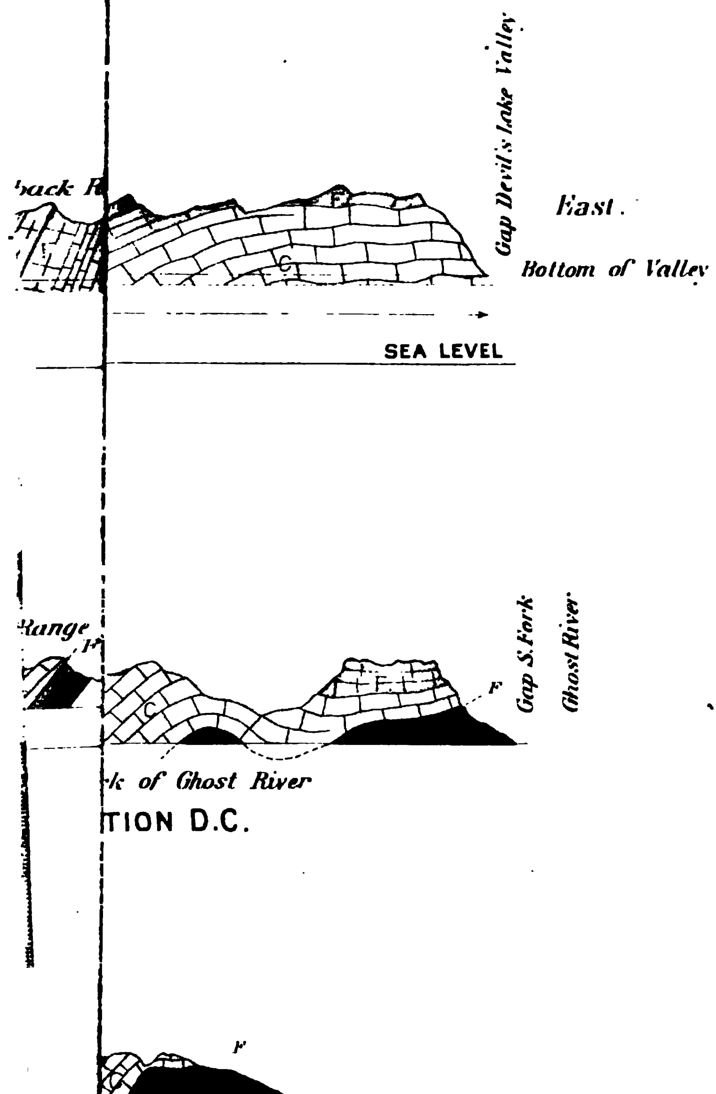
In the Otter-tail district, the Otter-tail Gold and Silver Mining Company have worked three claims during the season. One of these, the "Louis" claim, is situated directly under the railway track, about one and a quarter miles east of the Otter-tail station; the other two are on the east side of the creek, about a mile and a half up the stream from the railway crossing. A good road has been constructed from the railway to the mines, and effective preparations made for handling the ore. A little farther up, the Otter-tail is joined from the south by the

Wet-feet Creek, on which is situated the "Copper Bonanza," one of the best seams in the district. A large number of other claims have been staked out, one company alone owning twenty, within a circuit of a few miles; but, with the exception of those mentioned above, none are being worked at present. The uncertain state of the mining laws, and the extra expense and trouble necessitated by having to register both with the Dominion and Provincial Governments, is largely responsible for this state of affairs. The ore in this locality is an argentiferous galena, associated with some copper, zinc and traces of gold, and occurs in small quartz or calcite veins running parallel, or nearly so, to the strike of the calcareous schists, shales and limestones, which form the country rock of the district. The seams are small, seldom exceeding eighteen inches in thickness, but the ore is reported to contain a high percentage of silver. A stamping mill has been put up near the Canadian Pacific Railway crossing of the Ottertail, by the "Rocky Mountain Mining and Ore Reduction Company," and the ore from the different mines is now crushed and concentrated before shipment.

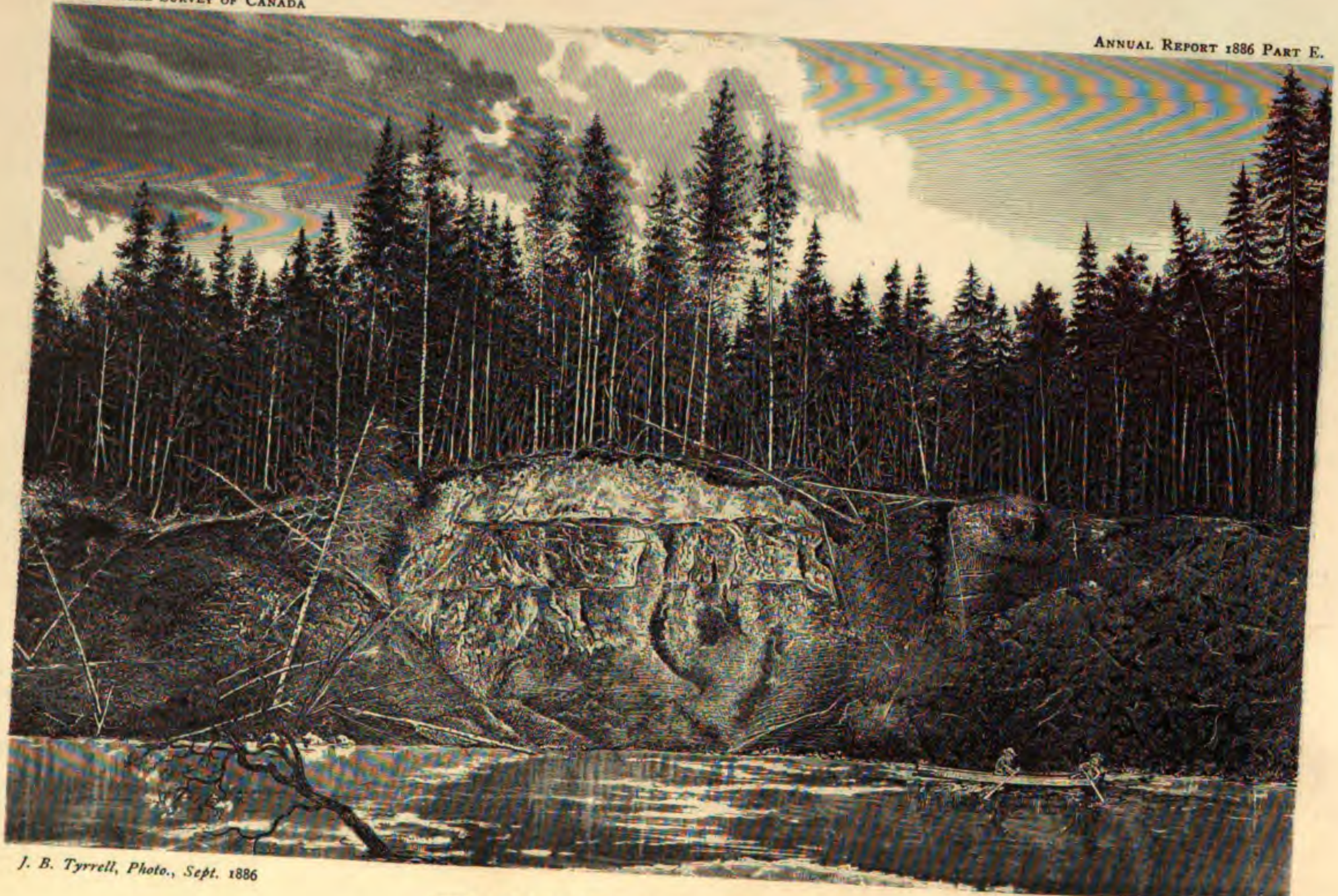
Near Field, Messrs. Coffman & Weitman have opened up the "Monarch" and "Cornucopia" claims in Mount Stephen, and the former especially now presents a very favorable appearance, showing over six feet of solid galena. The ore here is deposited in what miners call a "blanket-lode," and appears to impregnate a zone of interbedded calcareous rocks. It has been traced along the face of the mountain for several hundred yards, and, since I was there, Mr. Pattie, of Carleton Place, by blasting out a trail around an almost vertical cliff, has been enabled to explore it still farther, and reports the discovery of a nine-feet deposit. The galena is low-grade in silver, containing only from four to eleven ounces to the ton, (see assays 19-22, Part M, Annual Report of the Geological Survey for 1885,) but possesses compensating advantages in the extent of the deposit, the easy and comparatively inexpensive manner in which it can be worked, and in its proximity to a railway station.

A vein of calcite, flecked through with grains of cinnabar, is being opened near Golden City, and is interesting as being the only deposit of the kind known in the entire region.

4



The Burland Lithographic Company, Montreal



J. B. Tyrrell, Photo., Sept. 1886

Mortimer, Lith.

THICK COAL SEAM NORTH SASKATCHEWAN RIVER.

45 MILES ABOVE EDMONTON

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON A PART OF

NORTHERN ALBERTA,

AND PORTIONS OF ADJACENT DISTRICTS OF

ASSINIBOIA AND SASKATCHEWAN,

EMBRACING THE COUNTRY LYING SOUTH OF THE NORTH SASKATCHEWAN RIVER AND NORTH OF LAT. 51° 6′, BETWEEN LONG. 110° AND 115° 15′ WEST.

BY

J. B. TYRRELL, B.A., F.G.S.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1887.

TO ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg herewith to submit a report, with illustrative maps, on the geology and natural resources of part of Northern Alberta, and the western portions of the Districts of Assiniboia and Saskatchewan. Although to a certain extent preliminary, and by no means exhaustive in its nature, on account of the short space of time in which it was necessary for me to examine so large a tract of country, this report will, it is hoped, serve as a sufficient guide, for the present at all events, to point out the extent, position and character of the mineral wealth of the district.

I have the honour to be,

Sir,

Your most obedient servant,

J. B. TYRRELL

OTTAWA, 1st June, 1887.

NOTE.

The elevations given throughout this report are partly those determined instrumentally by the engineers of the Canadian Pacific Railway, partly those given in the "Report on the Canadian Pacific Railway, 1877," (old location) which have also been determined instrumentally, wherever it has been possible to fix the point to which the elevation there given refers, but for the most part they have been determined by readings taken with a mercurial barometer and two aneroids in 1886, with two aneroids in 1885, and with one aneroid in 1884, compared with readings taken regularly by the Meteorological Service at Calgary, Medicine Hat, and Edmonton. The heights of the first two of these three places have been fixed from the railway survey, while the height of the cistern of the barometer at Edmonton is taken as 2210 feet.

The bearings are everywhere given with reference to the true meridian.

The invertebrate fossils have been determined by Mr. J. F. Whiteaves of this Survey; descriptions and figures of the new species here mentioned being given in his "Contributions to Canadian Palæonlology, Vol. I., Part 2," while for the determination of the plant remains, I am indebted to the kindness of Sir J. W. Dawson of Montreal.

Our thanks are also due to Capt. E. Deville, Surveyor-General of Dominion Lands, and to the officers under him, as well as to Mr. G. U. Ryley, Clerk of Timber, Mineral and Grazing Lands, for placing plans of all the surveys made within the district at our disposal, also to Mr. Charles Carpmael, the Director of the Meteorological Service, and to the observers at Calgary and Edmonton, for the barometer readings taken by them during 1884, 1885 and 1886.

REPORT

ON A PART OF

NORTHERN ALBERTA,

AND PORTIONS OF THE ADJACENT DISTRICTS OF

ASSINIBOIA AND SASKATCHEWAN.

The district described in the following report, and embraced in the map which accompanies it, lies between the 51st and the 54th parallels, north latitude, from longitude 110° to 115° 15′ west, including an area of over 45,000 square miles, the greater part of which is situated in the northern portion of the District of Alberta; but the western edge of both the districts of Assiniboia and Saskatchewan has been included, as it is generally impossible to make natural geological boundaries coincide with political ones. The area is drained in its southern portion by the Red Deer River and the tributaries which flow nto it, and in its extreme south-western corner by the Ghost River and a few small streams which likewise flow into Bow River, all which waters find their way into the South Saskatchewan. In its northern portion it is drained by the North Saskatchewan with its tributary Battle River, and by the other smaller streams which join these two main waterways. **Region covered by report and map.** **Rivers draining the area.**

The three different kinds of country commonly found in the West, namely, prairie, partly wooded country, and forest; are represented within the limits of this district. Of these the two former constitute the greater part of the surface, while the area of forest is small, consisting only of the Beaver Hills and the district stretching south-westward from Edmonton, south of the Saskatchewan and west of the Pigeon and Battle lakes, and within the disturbed region of the foot-hills shown in the south-western corner of the map, though small patches of thickly wooded country may occur here and there in the half-wooded area. The prairie or Great Plains here find their north-westerly boundary, which latter may be defined in general terms as follows:—Beginning ten miles west of Calgary at the Bow River, thence north **Three kinds of country.** **Forest area.** **Extent of prairie.**

thirty-five miles to the Morley Edmonton trail, along this trail to the Lone Pine, then on a bearing averaging about twenty degrees north of west to the easterly limit of the map. South of this line lies the wooded district north of the Neutral Hills, which may be regarded as a sort of outlier of the half-wooded country towards the northern edge of the plains. With the exception of the small forest areas mentioned above, the rest of the region consists of half-wooded country, with groves of poplar and willow, separated by open glades and grassy stretches of greater or less extent. This part is thus most attractive, both to the traveller in search of natural beauties and to the would-be settler looking for a place where to make for himself a comfortable home in the shortest possible time.

Partly wooded country.

Ranching country to the south.

The region to the south had already been explored, and its main geological and topographical features clearly shown by Dr. G. M. Dawson in the Geological Survey Report for 1882-84. Its capabilities as a ranching country have now been proved beyond dispute by experiment. But it was felt that something more should be known of the great region lying to the north of this essentially ranching district; the great fertility of which as an agricultural country has already been pointed out by Dr. Selwyn, Prof. Macoun and many others who have travelled through it, while the deposits of coal in it seem to be practically inexhaustible. Especially towards the north, however, the country is thickly covered with drift deposits, through which very few streams cut down to the underlying rocks. Added to this, its generally wooded surface so completely shuts off the view for any considerable distance, that it would be impossible to make out some of the minute details of the geology without examining the country foot by foot and, in some cases, even without boring, either of which would require a much longer time than I had at my disposal.

Difficulty of geological exploration.

Geographical basis of map.

I have taken as a geographical basis in the preparation of the accompanying map, the surveys made by the Dominion Lands Department. The surveyors employed by that Department have instrumentally run east and west base lines, and meridian township-outlines, through the greater portion of the district, and subdivided the townships in the vicinity of settlements, as well as traversed the Red Deer, Battle and North Saskatchewan rivers through subdivided townships. Mr. Doupe, one of the surveyors, has also made an excellent micrometer traverse of the last-mentioned river from Rocky Mountain House to the western limit of the subdivided country. The upper courses of the Red Deer and Clearwater rivers are laid down from plans of timber limits filed in the Government Timber Office in Ottawa.

The distinctive character and contour lines of the hills and lakes, and the courses of the rivers outside the subdivided country in the more open districts, have been laid down from odometer surveys made by myself in 1884, by Mr. H. Hamilton, my assistant, in 1885, and by Mr. D. B. Dowling, my assistant, in 1886, and from canoe traverses made by myself in all three years, while the topography of the Beaver Hills and other thickly wooded tracts have been plotted from track-surveys made by myself, the bearings being taken with a prismatic compass, and the distances estimated chiefly from the time occupied on each course, checked by latitudes taken with a sextant of seven-inch arc. Methods of survey.

The names employed are chiefly those found on Hector and Palliser's map of 1863, or on the Dominion Land map of 1886; but when others have been considered necessary, those used by the Cree Indians or English translations of them, have been inserted; or if, as in some cases, these names would have led to confusion with other places not far distant, liberty has been taken to apply such new ones as may be thought appropriate. Names employed.

FORMER EXPLORATIONS.

Of the earlier explorations of this region, the first of which any record remains was sent out by M. Bigot, the Intendant, and de la Jonquière, the Governor of Canada in 1750, under the command of M. Legardeur de Saint-Pierre, to find a route to the western sea by the Saskatchewan River, which had been discovered and ascended as far as the Forks by one of the sons of M. de la Verendrye in 1748. Both M. de Saint-Pierre and his lieutenant, M. Boucher de Niverville, were overcome by the difficulties of the journey, and obliged to turn back, but some of their men pushed on and succeeded in reaching the mountains, where they founded Fort La Jonquière in 1751, at a distance, as stated by M. de Saint-Pierre, of 300 leagues beyond Fort Paskoya, on the Paskoya (or Saskatchewan) River, near the mouth of Carrot River. Earliest explorers of the region, 1750. Fort la Jonquière.

I am unable to find out whether these men ascended the north or the south branch of the Saskatchewan above the Forks, but it is probable that they followed the north branch, as the Indians along its banks belonged to the friendly tribes that had been known for some time around Lake Winnipeg, while the tribes on the plains to the south-west were always understood to be very fierce and hostile.

At all events, as these intrepid voyageurs were the first to reach the Rocky Mountains in Canadian territory, the expedition is worthy of notice, even though their route and the position of the fort founded by them be undeterminable.*

The next expedition of which I find any mention, is that of Mr. Fidler, whose route is laid down on Arrowsmith's map of North America, 1811. He started from old Fort George, which was situated on the north branch of the North Saskatchewan River, four and a half miles above the mouth of Moose Creek, in 1792, and travelled in a south-westerly direction, crossing the Battle, Red Deer and Bow rivers, reaching apparently as far south as the Little Bow River, or Willow Creek, near the base of the mountains. In 1793 he returned to the Saskatchewan, by a route a little east of the one that he had followed going out, crossing the Red Deer at the mouth of Rosebud Creek, which he calls "Edge Coal Creek," opposite which the following note is written on the face of the map: "Great quantity of coals in this creek." With the exception of the coal-seam mentioned by Sir Alex. Mackenzie as having been seen by him on Great Bear River in 1789, this is the first record of the discovery of coal in the Canadian North-West Territory.

Fidler, 1792.

First record of coal in the N. W.

But one of the most indefatigable of the early explorers was Mr. David Thompson, an officer of the North-West Fur Trading Company, who at the close of the last and at the beginning of the present century, travelled and traded throughout the country between Lake Superior and the Pacific. An enthusiastic geographer, neither the adventures of the journey nor the business of trade, hindered him from making a survey of some kind, of the route he was traversing, or when remaining at a post or "House," of determining, as far as possible, its true position by numerous astronomical observations, and it is much to be regretted that the results of his work have, up to the present, remained almost entirely in manuscript.

D. Thompson, 1798-1807.

From his field note-books, which the Crown Lands Department of Ontario has kindly allowed me to consult, the following notes with regard to his travels have been hurriedly gathered:—

Journeying westward in the autumn of 1798, he called at Fort George on his way to Lac La Biche, and in the spring of 1799 spent a few weeks at Edmonton, then known as Fort Augustus, before going north to the Athabasca River and Isle à la Crosse. In March, 1800, he made a hasty survey of the trail then used on the south side of the river, between Fort George and Edmonton, and on the fourth of May embarked at Rocky Mountain House and descended the Saskatchewan in a boat, reaching Fort George on the twelfth of May, and the Grand Rapids, at the mouth of the river, on the sixth of June, making an

His explorations.

*Les Varenne de Verendrye, by Pierre Margry in Revue Canadienne, 1872. Mémoire ou Journal de Legardeur de Saint-Pierre, in the Canadian Archives Office in Ottawa, and published in "Report of Canadian Archives by Douglass Brymner, archivist, 1886. Ottawa, 1887.

excellent track-survey for the whole of the distance. He saw the outcrop of the "Big Coal-Seam," but as its face had crumbled down and was largely covered with wet earth, he speaks of it as "crude bitumen mixed with earth" oozing out of the bank about eight feet above the surface of the water. In October of the same year, he started on horseback from Rocky Mountain House, and taking the trail up the west side of Clearwater River, reached the Red Deer, which he followed for a considerable distance into the mountains to a large camp of Kootanie Indians, whom he induced to return with him to the "House." On the seventeenth of November he again set out for the south, and came to the Bow River, not far from the present site of Calgary, continuing along its banks in a direction a little south of east as far as the mouth of Spitcheo or High River, where a large band of Piegans had pitched their camp. After spending a few days in establishing friendly relations with these Indians, he turned back and followed the Bow River a short distance into the mountains, and then struck northward from about the vicinity of Morley to Rocky Mountain House. In the summer of the same year Duncan McGillivray, apparently acting under Thompson's instructions, and starting from the Post last mentioned, followed the Saskatchewan to its source in a small lake in the mountains, and even crossed the summit and descended a short distance down Blaeberry River. Thomson's explorations. D. McGillivray

In 1801, Thompson made a track-survey of the route between Rocky Mountain House and Edmonton, apparently following a trail which led south of Gull Lake, and finally, in 1807, he left Rocky Mountain House.* He followed the Saskatchewan to its source in the mountains, and crossing the summit in latitude 51° 48′ 25″ on his way to the west coast, descended to the Columbia, down a stream which flows into the latter in latitude 51° 30′, evidently the Blaeberry River.

In 1814, Gabriel Franchère left Fort George or Astoria, at the mouth of the Columbia River, and crossed the mountains by the Athabasca Pass; then travelling by way of Athabasca River and Lac La Biche, he reached the Saskatchewan near the mouth of Dog Creek, a short distance above Fort George. From this point he descended in a canoe to Lake Winnipeg, which he reached on the twenty-fifth of June, having been two months and twenty-one days from the Pacific coast.† Though there is nothing of geological interest in his narrative, it G. Franchère, 1814.

* There were, in the North-West Territory, three trading-posts which commonly went by the name of Rocky Mountain House, one on Peace River, also known as Hudson's Hope; one on the Athabasca, now generally known as Jasper House, which was a supply post on the old traders' route through the mountains, and described by Ross Cox, Franchère, and others of the older travellers, and the post on the Saskatchewan, near the mouth of the Clearwater, which is marked as Acton House on some of the older maps. The third only is so named in this report.

† Narrative of a Voyage to the North-west Coast of America, in the years 1811, 1812, 1813 and 1814, by Gabriel Franchère. English Edition, New York, 1854.

abounds in lively descriptions of the country passed through, and of the manners of the native tribes with whom he came in contact, more especially, however, those on the western side of the mountains.

T. Drummond, 1825.

In the summer of 1825, Thomas Drummond, assistant naturalist in Franklin's second overland expedition,* ascended the Saskatchewan as far as Edmonton on his way to the mountains, and in the spring of 1827 returned east along the banks of the same river, collecting specimens of plants and animals, which were afterwards described by Sir Wm. Hooker and Sir John Richardson.

D. Douglass, 1827.

In this latter year, David Douglass† crossed the mountains from British Columbia by the Athabasca Pass, and reaching the Saskatchewan at Edmonton also descended it on his way east, being engaged, like Drummond, in collecting botanical and zoological specimens.

Sir G. Simpson, crosses the N. W., 1841.

In the summer of 1841, Sir George Simpson,‡ Governor of the Hudson's Bay Company, crossed the northern and western portions of the district on his journey across the continent. Turning to the south side of the Saskatchewan at Fort Pitt, he followed, as far as we can learn from his narrative, the trail travelled also by Dr. Hector in the spring of 1859; passing the "chain of lakes" at the source of Vermilion River, and going north of the Beaver Hills, he reached Edmonton on the evening of the fourth day from Fort Pitt. From Edmonton he directed his course more to the south, camping on the first night at Smoking Weed Creek, now known as Pipestone Creek, and on the second by the shore of Gull Lake. After fording Blind Man River, he reached Reedy Lake, probably "Swan Lake," beyond which he passed over the ridge of hills to the south-west, and following the wide open valley of Medicine River, crossed the Red Deer at the old ford, and thence directed his course to the cañon on the "La Biche" or Little Red Deer River. Here he turned westward, sometimes tracking up the river, and sometimes wading through deep swamps, till he reached the Devil's Lake Gap, where he entered the mountains. His narrative is very racy, and deals rather with the incidents of the journey than with the country passed through. In giving a short account of Edmonton, however, he mentions the occurrence of coal in the river banks close to the town, and though the thickness of the deposit is greatly exaggerated, it is one of the first notices that we have of the existence of coal on the Saskatchewan.

First notices of coal on the Saskatchewan.

Sir John Richardson, in 1851, makes the following mention of the presence of coal in the same locality: "Mr. Drummond procured me

* Narrative of a Second Expedition to the Shores of the Polar Sea, by John Franklin, Capt. R. N., pp. 304-313.

† For an account of the wanderings of David Douglass in America, Hooker refers to the "Companion to the Botanical Magazine, vol. II.," which, however, to me has been inaccessible.

‡ Narrative of a Journey round the World, by Sir Geo. Simpson, London, 1847, vol. I. pp. 97-114.

specimens of coal with its associated rocks at Edmonton, on the north branch of the Saskatchewan," and "clay ironstones occur in the clay beds" which are found in the same section with the coal seam. He considers these beds, with the coal-bearing horizon on the Mackenzie River, as of Tertiary age.*

In the autumn of 1845, Father De Smet came across the Rocky Mountains from British Columbia through the White Man's Pass, reaching first Rocky Mountain House, and then Fort Augustus or Edmonton. From the mouth of White Man's Pass he appears to have ascended Bow River, crossed over to the Red Deer and probably afterwards to James River, following the old trail down this stream till it crossed to the Clearwater, down which he turned to the Mountain House. In his account of the journey, he speaks of seeing coal on one of the branches of the Red Deer "apparently very abundant," adding "that it abounds east of the mountains on the Saskatchewan and Athabasca." It is probable that the former remark refers to a coal-seam which is reported by the Indians as cropping out on James River, inside the area of the foot-hills.* De Smet, 1845.

But by far the most interesting and important expedition which has visited and explored this district, was that sent out by the British Government under the command of Capt. Palliser, assisted by Capt. Blackiston, with Dr. Hector as geologist, and M. Bourgeau as botanist.

In the summer of 1857 the expedition reached Fort Carleton, whence Capt. Palliser returned east for the winter, while Dr. Hector went on as far as Rocky Mountain House with a dog-team, travelling overland on the journey up and returning on the river. In the spring of 1858, after the arrival of Capt. Palliser, the whole party set out from Carleton, and after rounding the Elbow of the Saskatchewan, kept a course almost due west, crossing Battle River a little below and again a little above the Elbow, and passing south of Buffalo Lake, across Tail Creek and Red Deer River, reached a point on Rosebud Creek, where they split up into four smaller parties. Capt. Palliser kept to the south, spending the rest of the summer on the plains or in the mountains beyond the limits of the present map, returning to Edmonton on the 20th of September. Dr. Hector turned west to the Old Bow Fort, and then into the mountains, coming out by the Saskatchewan from Rocky Mountain House, keeping the winter trail by the north end of Gull Lake to Edmonton, which he reached on the 7th of October. Capt. Blackiston went south to explore the North and South Kootanie Passes, while M. Bourgeau went west into the mountains in search of Capt. Palliser's expedition, 1857-1859.

* Journal of a Boat Voyage through Rupert's Land, p. 195.

* Oregon Missions by Father P. J. De Smet, New York, 1847, pp. 159-160.

Explorations by Dr. Hector.

plants. On the 22nd of October, Hector started on a nine days' exploring tour down the Saskatchewan, and on the 26th of November undertook an excursion to Ghost River, taking what is now the Edmonton-Calgary trail to the mouth of Blind Man River, then after following up the Red Deer River for a considerable distance, turned south to Little Red Deer River, entering the foot-hills at the cañon on this stream, which he followed up to Prairie de la Graisse, across which he passed to Ghost River. On the return trip he followed the old trail which crosses Dog Pond Creek at its mouth, and Red Deer River a short distance below the confluence of the Little Red Deer, reaching Edmonton again on Christmas-eve. The rest of the winter was spent by him in making an excursion to Jasper House, on Athabasca River, while Capt. Palliser remained in the vicinity of Edmonton and Rocky Mountain House hunting buffalo and making what arrangements were necessary for the next season's work.

In the spring of 1859, Dr. Hector, who had gone down to Fort Pitt to attend to a number of cases of sickness there, returned to Edmonton, making an odometer survey of the trail followed, and then this expedition started south to the Hand Hills, and thence, first south and then west, across the mountains into British Columbia, returning to England from the west coast. This exploration furnished us with the first serviceable map of the North-West Territory, and from a geological standpoint, it showed the existence of a great coal-bearing area of Cretaceous and Tertiary rocks extending from the Laurentian axis on the north-east to the Rocky Mountains on the west, and in a paper published in the *Edinburgh New Philosophical Journal* for October, 1861, Dr. Hector first recorded the occurrence of gold in the Saskatchewan.*

Map of the North-west.

Later explorations.

Succeeding explorations are too well known to require more than a passing notice here, especially as most of them followed closely the banks of the Saskatchewan, and added very little to our previous knowledge of the country, the two exceptions being those of Dr. Selwyn and Prof. Macoun, both of which will be found mentioned later on in this report.

Earl Southesk, 1859.

In the summer of 1859 the Earl of Southesk, impelled by a desire for novelty and a love of sport and travel, crossed this district on his way to and from the mountains,† and in 1863 Lord Milton and Dr. Cheadle followed up the North Saskatchewan as far as Edmonton, on their way to the gold regions of British Columbia.‡

Milton and Cheadle, 1863.

*For full account of this expedition, see "The Journals, Detailed Reports and Observations relative to the Exploration, by Captain Palliser," with accompanying "Index and Maps." Government, London, 1863.

† "Saskatchewan and the Rocky Mountains," by the Earl of Southesk. Edinburgh, 1875.

‡ "The North-West Passage by Land," by Viscount Milton and W. B. Cheadle, M.A., M.D., &c.

In the autumn of 1870, Capt. Butler was sent out by Governor Archibald of Manitoba to establish some civil authority in this western district, and to enquire into the cause and extent of the ravages of small-pox among the Indians. He reached as far west as Rocky Mountain House, returning to Manitoba before the end of the same year.* Capt. Butler, 1870.

In 1873, Dr. Selwyn travelled from Fort Garry to Rocky Mountain House and back. Leaving Fort Pitt on the 31st of August, he followed the trail on the north side of the river to Edmonton, where he crossed the Saskatchewan and followed the Hudson's Bay Company's cart trail to Rocky Mountain House. Here he secured a boat from the officer in charge at the fort, and descended the Saskatchewan to its mouth, making a track-survey of the course of the river, as well as a geological examination of its banks. Besides a number of interesting observations on the horizons of the different beds seen in the course of the journey, he was the first to record the existence of the "Big Coal-Seam" outcropping near Goose Encampment, about half-way between the mouth of Brazeau River and Edmonton, as well as to recognize the great extent of the coal deposits over the surrounding area.† Dr. Selwyn, 1873.

In 1875, Dr. R. W. Ells, who was in charge of the boring operations carried on at Fort Carleton, descended the Saskatchewan from Rocky Mountain House to the above fort, collecting specimens of the economic minerals of the country for the Centennial Exhibition at Philadelphia,‡ and in 1879 Dr. Dawson and party passed through the district on their way east, after the examination of the Peace River Pass.§ Dr. Ells, 1875. Dr. Dawson 1879.

In the same year, Prof. Macoun crossed the plains in a south-westerly direction from Battleford to the Hand Hills, touching on his way the south-east angle of Sounding Creek; then, fording the Red Deer, he went on to Blackfoot Crossing, and thence west to Morley, while his assistant, Mr. Wilkins, turned north to Tail Creek, then east past the Neutral Hills and Sounding Lake to Battleford. From Morley Prof. Macoun followed the old trail north to a distance beyond Leavings on Battle River, when he turned to the north-east towards Hay Lakes, and then a little south of east past Flag Hill, across Battle River, and passing to the north of the wooded rolling hills, reached Fort Pitt and the Sounding Lake trail, which he followed north for a short distance, and then turned east towards Battleford, being the last on the list of explorers who traversed that country before the Canadian Pacific Railway provided an easy means of access into it, making the journey from Winnipeg a matter of a few hours only, instead of several weeks as formerly. Prof. Macoun, 1879.

* "The Great Lone Land," by Capt. W. F. Butler. London, 1873.
† Geol. Survey Report for 1873-74, pp. 17-65.
‡ Geol. Survey Report for 1785-76, pp. 287-289.
§ Geol. Survey Report for 1879-80.

GENERAL PHYSICAL FEATURES.

General character of the country.

The general character of the country is that of a sloping plain, breaking into abrupt ridges to the south-west, where a small area of foot-hills is included. From the base of these hills, which attain a height of 5000 feet above sea-level, the country declines to the north-east, sloping off from an altitude of 4000 feet, along the eastern edge of the foot-hills, to 1650 feet at Fort Pitt, on the Saskatchewan. The slope, though fairly regular, taken as a whole, is, however, broken by numerous high hills and deep river channels. These latter follow the general direction of the present slope of the country till they get beyond the edge of the compact sandstones of the Upper Laramie, when they turn to the east or south-east, the North Saskatchewan being again, however, diverted to the north by the more thickly drift-covered region of the Beaver Hills, while the Red Deer turns almost due south, adopting the channel down which Trail Creek flows from Buffalo Lake, its direction in this southerly stretch being slightly opposed to the general inclination of the country.

Principal hills and their altitudes.

Of the hills which rise above the surrounding level, the principal ones are the Hand Hills, which form an irregular plateau 3550 feet above sea-level and more than 1300 feet above the Red Deer River at their base, with a gentle prairie slope to the east and an abrupt escarpment towards the west. On the opposite side of the Red Deer, Wintering Hills attain a height of 3225 feet, faced by a steep escarpment towards the north-east, and falling off gradually to the plain on the south and west. The Neutral Hills are high, broken ridges rising westward to the "Nose" to an elevation of 2970 feet, while to the north the country is, to a large extent, made up of rolling, sandy ridges, partly wooded with aspen, with intervening valleys which are dotted with fresh water lakes. North of Battle River the Blackfoot Hills, 2400 feet in height, are seen as rolling, lightly-wooded ridges. The Beaver Hills, south-east of Edmonton, with an elevation of 2500 feet, are densely-wooded, sandy ridges, separated by wide marshes, or "beaver meadows," made by beavers, that have dammed back the small streams which run out from among the hills. Besides those already mentioned, the following are conspicuous and important land-marks: Knee Hills, 3075 feet; Three Hills; Surcee Butte, 3005 feet; Antler Hill; Flagstaff Hill; Peace Hills, 3600 feet; Bear Hills; Medicine Lodge Hills, 3500 feet; Hawk Hill; Nose Hill, 3900 feet; Big Hill, 4250 feet, and, as we approach the mountains, numerous ridges, which often rise in places to a considerable height, cross the country in a north-westerly and south-easterly direction.

Lakes, however, as well as hills, are numerous and form conspicuous natural features. Some of them, which lie in the western and more thickly-wooded part of the district, have outlets carrying off a considerable quantity of water, but many others, which lie on the impervious clays of the Edmonton series, are merely evaporating basins, either now without an outlet or with one which carries water only in seasons of flood. The latter are generally more or less alkaline, and often of a milk-white colour from suspended clayey matter. Among them, however, a few, such as Beaver Lake, have outlets with running water all the year round. Lakes.

The following is a list of some of the more important lakes, with their approximate elevations:— Elevations.

	Feet.
Egg Lake (near Victoria)	1997
Birch Lake	2140
Sounding Lake	2140
Beaver Lake	2178
Wavy Lake	2260
Hastings Lake	2380
Cooking Lake	2400
Buffalo Lake	2536
Dowling Lake	2563
Sullivan Lake	2620
Bear Lake	2624
Pigeon Lake	2824
Battle Lake	2770
Quill Lakes	2860
Little Fish Lake	2890
Gull Lake	2905
Devil's Pine Lake	2910
Buck Lake	2970
Egg Lake (in Hand Hills)	2970

The division of the country into the three classes mentioned above, namely, plains, half-wooded country and forest, is perhaps the most convenient classification that can be adopted for general descriptive purposes, though it will be of no service when we reach the essentially geological part of the report, and even here only serves to distinguish more or less indefinite areas.

The Great Plains occupy the southern and south-eastern portion of the district. West of Red Deer River they are broken by deep, often wooded, valleys, while to the east of the Red Deer and beyond the Hand Hills, they stretch away in a lightly rolling, grassy sward, unbroken by either high hills or deep valleys, and no wood is any where to be seen, except a few willows on two of the more sheltered The Great Plains.

creeks. The greater part of the soil is eminently fertile, and would produce all the ordinary cereals and root crops grown in eastern Canada. The want of trees might be felt for a time, but thrifty settlers would soon re-establish the groves which prairie fires, rather than drought or frost, have kept down, for there is every reason to believe that many of the hardier kind of trees would grow even on the more exposed parts of the prairie if they were preserved from destruction by fire. The timber or lumber needed immediately for building purposes can be floated down the Red Deer at small cost, and wood is not needed for fuel, as the supply of coal in the vicinity is practically inexhaustible. Good water can also be obtained almost everywhere, either in the brooks which drain the country or in the small lakes scattered over its surface.

Want of trees.

Good grazing country.

Though much of this part of the plains is, as we have seen, well adapted for agriculture, yet it is especially valuable as a grazing country, for the ground in winter is never covered with more than a few inches of snow, and the valleys, though shallow, are deep enough to protect herds against the storms.

Partly wooded country.

More to the northward, clumps of willow appear, and a little further on, groves of poplar occur around the lakes and on the northern slopes of the hills, spreading out in places so as to cover areas of considerable extent. We have now reached the partly wooded country. The soil has become richer and deeper, and, instead of the short buffalo-grass of the plains, the grass is longer and mixed with a thick growth of vetch and pea-vine (*Astragalus*, *Vicia* and *Lathyrus*), forming excellent pasture. This partly wooded country, lying between the Great Plains to the south and the forests to the north, has for many years attracted the favourable notice of travellers, and is even yet best known to many by the name "Fertile Belt," which was given to it by Dr. Hector in 1861.

The "Fertile Belt."

Forest area.

The forest area included in the district under consideration stretches along its western edge, with the Beaver Hills as an outlier. The surface is, for the most part, very uneven, consisting of high, sandy ridges covered with spruce and "cypress" or jack pine (*Pinus Murrayana*), some balsam, fir and birch being also found in the more northern parts.

Between these ridges are wide, marshy tracts, either covered with moss and forming impassable "muskegs," or bearing a thick growth of spruce and larch, through which it is equally difficult to travel. Some of these valleys, if cleared and drained, would doubtless furnish good agricultural land, though it is hardly likely that the necessity for cultivating them will be felt for some time to come. On the uplands much of the spruce is of excellent quality, and will, before long, be a source of considerable wealth to the country.

TRIBUTARIES OF BOW RIVER FROM THE NORTH.

The Bow River has already been described by Dr. G. M. Dawson in his "Report on the Region in the Vicinity of the Bow and Belly Rivers."* In the summer of 1881 he descended it in a canoe from Morley to its mouth, and on other occasions examined its valley from Morley to its source in the heart of the mountains. It remains, then, for us briefly to describe some of the small streams which flow into it from the north, draining but an inconsiderable area in the south-western corner of the district. Dr. Dawson's Report.

Ghost River, the largest of these streams, is a clear, rapid torrent, eighty feet wide just above its mouth, and at high water from five to six feet deep. It rises on the eastern flank of the outer limestone range of the mountains, and flows eastward over a wide bed of quartzite pebbles through a country thickly covered with small spruce and brulé. The upper part was examined in 1883 by Dr. G. M. Dawson as far east as a point lying north of Old Bow Fort, on the Bow River, the banks at that point being high and wooded. Ghost River.

Along the river down to its junction with the Bow, a distance of eleven miles, high gravel terraces are seen in the valley, those to the north being prairie-like and covered with excellent bunch-grass, those to the south being for the most part covered with windfall.

Between Ghost and Bow rivers, the country consists of irregularly rolling, partly wooded hills, with beautiful stretches of fertile land in the bottoms of the valleys and on the sloping hill-sides. These are covered with excellent grass, which is often mixed with astragalus, wild vetch and other leguminous plants which represent clover in the west, making one of the finest ranges for horses and cattle in the Territory. Grazing land between Ghost and Bow rivers.

North of Ghost River the country is of a much more regular character: high ridges, partly timbered, running in a north-westerly direction, separated by low, generally swampy valleys, down which larger or smaller brooks flow to join the main stream. One of these, known as the North Fork, and also rising in the outer range of the mountains, is of about equal size with the principal branch of the river which it joins seven miles above its mouth. Country further north.

From the mouth of Ghost River to the edge of the disturbed belt, as outlined on the map, three small streams flow into Bow River, draining as many wide, sloping and, in places, rather marshy valleys. A little to the east of these again, two similar brooks flow in deep, narrow valleys, from one hundred and fifty to three hundred feet below

* Geological Survey Report for 1882-84, pp. 29 C. et seq.

the surrounding plateau. The area drained by these creeks, and the country stretching east as far as the "Nose," are covered with good bunch-grass, wood is also plentiful in the deeper parts of the valleys and on sheltered hill-sides—in fact, wood, water and grass are here in abundance, and plenty of coal can be had from the seam which crops out near the mouth of Coal Creek.

Big Hill Creek. Big Hill Creek, the most easterly and largest of these five creeks, for four or five miles north of the Morley-Calgary trail runs in a valley from two to four hundred feet deep, and about half a mile wide at the top, the banks in some places being grassy, in others covered with poplar of fair size. **Big Hill.** The Big Hill, which lies south-east of this creek, between it and Bow River, is a high, rounded mass, doubtless of hard sandstone, rising 550 feet above the river at its base, its southern and western sides being covered with a thick growth of large and small poplar. From the Big Hill eastward, a high ridge runs north of Bow River, culminating in the "Nose," a round grassy hill, 500 feet high, lying five miles north-west from Calgary. This ridge is rolling, and broken here and there by small lakes and marshes, from which a large quantity of hay is now regularly cut.

Nose Creek. East of the "Nose," Nose Creek flows south into Bow River, receiving on the way a branch from the west. It is a small, clear stream, twenty-five feet wide and one foot deep at low water, flowing in an open, treeless valley a quarter of a mile wide and eighty feet deep at its mouth, but becoming wider and shallower towards the north. In the flats near the mouth the soil is good sandy loam, which, however, is gradually replaced up-stream by a hard clay. The uplands to the east are sandy, and bear a close growth of short nutritious buffalo-grass.

Watershed between Bow and Red Deer rivers. The watershed dividing the drainage areas of the Bow and Red Deer rivers outside the edge of the foot-hills begins about ten miles north of the Bow, and runs eastward for fourteen miles, crossing the Morley-Edmonton trail at an elevation of 4300 feet; thence it follows a north-easterly course, and crosses the Calgary-Edmonton trail twenty-eight miles north of Calgary, at an elevation of 3600 feet; thence it runs a little east of south along the east side of Nose Creek to "Spy Hill," keeping essentially the same elevation; thence eastward to Strathmore, on the Canadian Pacific Railway, at an elevation of 3005 feet; thence north-eastward around the head-waters of Crowfoot Creek, and thence south-eastward beyond the limits of this district.

Upper Red Deer and its Tributaries.

Little Red Deer River. The Little Red Deer, the most southerly affluent of the Red Deer River in the upper part of its course, rises like the Ghost River in the

outer limestone range of the mountains, a little north of the Devil's Head Mountain, and flows easterly for about nineteen miles as far as the crossing of the Stoney Pack-trail, where it is a clear stream fifteen feet wide and a foot deep. From this point it flows in an east-north-easterly direction for four miles, to the mouth of Tomuna Sipisis, or Grease Creek, through a narrow valley bounded by sandstone ridges, which recede a little in some places and leave room for high terraces. Grease Creek is a stream almost as large as the Little Red Deer, joining it from the north-west, and like it, flowing over a bed of quartzite pebbles. At its mouth, and for half a mile further east, there is a wide, open, grassy flat, the first pasture met with below the trail crossing, the banks being before covered with small spruce and poplar. The Little Red Deer now turns north-eastward for about two miles and a half, in a valley three-eighths of a mile wide, bounded by high, sloping, wooded hills, the bottom, through which the river winds from side to side, being covered with bunch-grass and dotted with groves of aspen and willow. For the next mile the river flows through a narrow gorge or "cañon," with rocky sides from fifty to two hundred feet high, and then turns to the north-east, and for five miles flows in a valley a hundred feet deep and a quarter of a mile wide at the bottom. The flats for the first four miles are well covered with excellent bunch-grass, the stream being bordered by a fringe of willows and poplars, and the sloping sides of the valley wooded with small aspens. For the last mile, however, the flats are swampy and covered with a dense growth of spruce. The valley then turns to the east, retaining this latter character, the bottom being covered with rather small spruce and the sloping banks being either partly wooded or grassed. After running east for four or five miles, it turns abruptly to the north, and for eighteen miles the river flows along the bottom of a valley from one to two miles wide, the sides of which decline gradually from the higher plateaus to the east and to the west, the slopes being partly covered with poplar, with some spruce in the small transverse gulleys, and partly with low willow and birch scrub, under which there is a close grassy sward. The bottom land is often marshy and timbered with good spruce. At the end of this stretch the river turns abruply to the east, leaving the valley just described,—which however continues on and joins that of the Red Deer about eight miles further north,—and runs for three miles in a narrow irregular valley a hundred feet deep, with steeply sloping sides covered with grass or small poplars. About two miles north of this part of the river is a rounded hill five hundred feet high, and well wooded to the summit. The Crees call it Kihlawătis, or Eagle Hill. After a course of three miles to the east-north-east in a narrow channel bounded to the north by partly wooded terraces, the Little Red Deer

Grease Creek.

Little Red Deer River.

Wide valley.

Eagle Hill.

Dog Pound Creek.

is joined by the Ko-ma-tasta-moin Sipisis, or Dog Pound Creek, a small clear stream twenty-five feet wide and twenty inches deep, flowing over a bed of quartzite pebbles. This tributary rises in the high ground about twelve miles north of Bow River, a little to the west of the edge of the prairie, the small brooklets collecting into two main branches, which after their junction flow northward for seventeen miles in a sloping valley very similar to the corresponding one further west, occupied by the Little Red Deer, but much more open and grassy, the west side alone bearing timber of any considerable size, the east side being prairie dotted with willow bushes and a few aspen groves.

Lower course of Little Red Deer River.

From the mouth of the Dog Pound, the Little Red Deer flows north-east for eight miles to the crossing of the Rocky Mountain House trail, in a valley the sides of which are largely wooded with poplar or small spruce, and the flats often clear and covered with good bunch-grass; it then flows in a winding channel for about fourteen miles to its confluence with the Red Deer, bordered in many places with thick groves of spruce, through beautiful prairie slopes reaching from its edge up to the level of the surrounding country.

Country west of Little Red Deer River.

Between the Little Red Deer River and Fallen Timber Creek, the country is made up of a series of longitudinal ridges, running north-west and south-east, for the most part thickly wooded with spruce and poplar. These decrease in height towards the east and are separated by flat, swampy valleys. Further east, between Little Red Deer and Red Deer rivers, a considerable portion of the area is covered with hay-marshes, around which are growing thick groves of poplar, willow, and occasionally spruce. The soil, a rich dark sandy loam, would make excellent farming land when drained, which could be done quite easily.

Rich soil.

Fallen Timber Creek.

Kow-ich-ti-kow Sipisis, or Fallen Timber Creek, is another affluent of the Red Deer from the south. At its mouth it is a rapid clear stream, thirty-five feet wide and two feet deep, with a bed of quartzite pebbles. It rises in the outer range of the mountains a little north of the source of the Little Red Deer, and flows in a north-easterly direction to the crossing of the Stoney pack-trail. From here it flows a little north of east, being bounded on the south first by high spruce-covered hills and then by low ridges with wide intervening swampy valleys; to the northward are low rolling hills, sparsely covered with a scattered growth of pine, spruce and poplar. At the western edge of range five, west of the fifth principal meridian, the swampy land disappears for a time, the creek, which has here a breadth of twenty feet, running south-easterly for from two to three miles through low dry flats. It then turns abruptly to the north, and after a course of eleven miles flows into Red Deer River. For seven miles from its mouth, it runs

through a marshy valley, which is bounded on the east by conspicuous wooded ridges, and on the west by a wide shingle flat, covered with dwarf birch and willow, and which stretches back to a ridge covered with a dense forest of large spruce.

COUNTRY DRAINED BY STREAMS FLOWING EAST INTO RED DEER RIVER.

Lying north of the watershed line between the Bow and Red Deer rivers, for the most part east of the Calgary-Edmonton trail, and south and west of Red Deer River, is a tract of land about 3400 square miles in extent, drained by several small streams, which flow eastward into the latter river. The highest ridge of this area begins at Spy Hill, north-east of Calgary, with an elevation of 3600 feet, and runs north along Nose Creek to the ridge at its source, retaining essentially the same elevation. From this line as a base the country slopes off to the north and east, the elevation of the Red Deer River at the ferry being 2750 feet, and at the mouth of the Rosebud 2230 feet, which, allowing for the heights of the banks at each of these places, gives an average fall of thirteen and a half feet to the mile east and north from the above-mentioned line. **Western drainage area of the Red Deer.**

The district is drained by four main streams, which we will briefly notice in order, from south to north.

Rosebud or Arrowwood Creek rises in some low, marshy lakes a short distance west of the Morley-Edmonton trail, at an elevation of 3450 feet, and flows directly south-east for forty-five miles in a beautiful valley from forty to seventy feet deep and about a quarter of a mile wide. This valley is almost entirely open, with sloping grassy banks, at the bottom of which lie fine grassy flats, though west of the 114th meridian a few poplars and willows are met with here and there on its steeper hill-sides and in lateral coulées running in from the south. Below this meridian, several small streams join it from the west, draining stretches of open, rolling prairie. To the north-east the country is almost level, evenly grassed, with a few small hay-swamps. Near the Morley trail, the prairie on both sides of the valley is somewhat marshy and covered with low willow scrub, under which is growing a close mat of coarse grass, but before the Calgary trail is reached, the willow scrub has quite disappeared, and from there eastward, the country is covered with a good growth of short buffalo-grass. **Upper course of Rosebud Creek.**

At the end of this south-easterly stretch the river turns sharply to the east, the banks immediately falling back for a considerable distance, leaving a wide grassy intervale, through which the stream winds in a very crooked channel for nine miles. The soil is a fine white silt, contrasting with the dark, sandy loam which covers most of the surround-

ing higher country. To the south-east, a range of low, drifting sand-hills, partly covered with willows and rose-bushes, and separated by small fresh water lakes, breaks with its irregular outline the even contour of the prairie horizon.

Lower course of Rosebud Creek.

At the eastern end of the wide flat the valley narrows to something like its former width, and continues in an easterly direction for eighteen miles. Its sides are generally grassy, though scarped at a few of the sharper bends, but, instead of being comparatively even as before, they are now broken by numerous coulées, which drain the higher lands on either side. Eight miles below the flat, wood again appears on the banks in the shape of small willows and serviceberry bushes (*Amelanchier Canadensis*), and the stream is blocked by numerous old beaver-dams. For the last seventeen miles before emptying into the Red Deer, the creek flows in an east-north-easterly direction in a valley which deepens rapidly towards its mouth, while the banks become very precipitous and the lateral coulées are filled with a thick growth of spruce.

Country to the south.

South of Rosebud Creek a high ridge runs east and west, culminating in the Wintering Hills. This is an elevated plateau, 3225 feet above sea-level, with a steep, though generally wooded, escarpment to the north. A level or slightly sloping plain, dotted with many small lakes, occupies the top of the plateau, and to the south it breaks into bare, rolling hills, with lakes in nearly all the intervening depressions; beyond, a plain stretches away to Cranberry Valley. Between the Wintering Hills and Rosebud Creek, the country is a good grassy prairie, dotted with small lakes, and broken by numerous deep and often wooded coulées; while north of the creek the lakes are fewer in number, and the land is drained by a number of coulées falling southward but carrying water only in wet weather.

Knee Hills Creek.

Knee Hills Creek, which is the next stream met with north of the Rosebud, is made up of two branches which rise respectively near the Lone Pine on the Edmonton-Calgary trail, and south-east of Antler Hill, then run south-east in shallow valleys or in the bottom of sloping troughs to their junction south of the Knee Hills. From this point it flows south-east for ten miles, the valley being open and shallow, wide flats occurring in many places on each side of the stream. The creek then turns to the east, and after a course of twenty miles, flows into the Red Deer eleven miles above the mouth of the Rosebud, its valley being of a very similar character to that of

Timber.

the latter. At the bend to the east, there is a considerable grove of poplar, and the south side of the valley is also covered with bushes of serviceberry, raspberry and gooseberry. Spruce also appears in the valley about nine miles above its mouth, where it is narrow and 200

feet deep. The sides of the valley are very much broken by lateral coulées, which run in from the high lands on either side.

Three Hills Creek rises in a small lake six miles east of Wavy Lake which latter is drained northward into the Red Deer, and flows south-south-eastward for fifty miles, being joined by Devil's Pine Creek, a stream of similar size to itself, five miles above its confluence with the Red Deer three miles north of the mouth of Knee Hills Creek. After issuing from the lake, it flows for five miles through partly wooded country, then traverses for the next five miles a wide clay flat, the wood receding to the hills on either side. The valley then becomes narrow for six miles, the country on both sides being slightly rolling and covered with good grass. The stream emerging from this narrow valley enters a wide flat, or rather the bottom of a sloping trough, from three to six miles wide. Fourteen miles further down, the valley again narrows in, and from there to the point where it opens into that of the Red Deer, becomes gradually deeper with more abrupt banks. The creek throughout its whole course is fringed more or less with willows, poplar appearing fifteen miles and spruce nine miles above its mouth. **Three Hills Creek.**

Devil's Pine Creek issues from Devil's Pine Lake, and flows south-south-east for thirty-eight miles to join Three Hills Creek. For five miles from the lake it runs between high ridges covered with poplars; then its valley, though shallow, becomes well defined, and from a quarter to half a mile wide, with sloping grassy banks. The bed of the creek is muddy, till about twelve miles above its mouth where it becomes stony. The water when it issues from the lake is beautifully clear, but it soon becomes of a yellowish green colour from suspended clayey matter. For the last six miles, the valley is steep, and the banks scarped. Here and there a few willows are seen, but little or no poplar till within six miles of Three Hills Creek. The country on both sides of the stream, in the lower part of its course, is slightly undulating prairie, covered with a fine growth of short buffalo-grass. **Devil's Pine Creek.**

Looking from the mouth of Knee Hills Creek, the country towards the north and west, is seen to be made up of four large valleys, separated by three salient ridges. The valleys are those of Knee Hills, Three Hills and Devil's Pine creeks and of the Red Deer River, the last, of course, cut down the deepest, but all well defined. The ridges which separate these valleys are open and covered with a thick growth of a grass very similar to the bunch-grass of the foot-hills. They rise from three to four hundred feet above the level of the bottom of the adjoining valleys. The first ridge culminates in the Knee Hills with an elevation of about 3,150 feet, the second, in the Three Hills with about the same elevation, and the third in the Surcee Butte and the **Confluent valleys.**

ridge which runs north from it, the Butte itself having an elevation of 3,000 feet.

Country north of the above streams. North of the sources of Three Hills Creek, and north and east of Devil's Pine Lake, there is a small tract from which there is either no drainage or the water is drained off northward into the Red Deer. In it some wide stretches of flat grassy land are met with, but the country is mostly composed of wooded ridges separated by partly wooded valleys or by rolling, partly wooded hills, among which lie a great number of small lakes. In most of these the water is fresh, but the Quill Lakes, **Quill Lakes.** which are the largest bodies of water in the district, are very saline, though a number of small lakes which surround them, lying at a slightly higher elevation, are quite fresh. In the summer and early autumn, these lakes abound with ducks, and in the streams further to the south there are still a considerable number of beaver.

Rosebud, Knee Hills and Three Hills creeks are about the same size at their mouths, being about twenty-five feet wide and eighteen inches deep at low water.

Red Deer River.

Source. The Red Deer River rises in one of the interior ranges of the Rocky Mountains, in lat. 51° 30′, long 116° W., close to one of the branches of Pipestone Creek, which flows westward into Bow River It leaves the mountains in lat 51° 43′, long 115° 23′ W., and flows easterly through the disturbed region of the foot-hills, reaching the crossing of the Stoney pack-trail a little east of long. 115° W., where our examination of it began. It is here a stream of clear blue water two hundred feet wide and two feet deep, flowing over a bed of large quartzite pebbles and boulders. **Upper course of Red Deer River.** Just below the ford it turns sharply to the north, following the west side of a high sandstone ridge, and is bordered on the west by a strip of bench land, half a mile wide, partly covered with fallen timber. After flowing northward for two miles, it turns again abruptly to the east, having been joined at the angle by William's Creek, a small clear stream fifteen feet wide and six inches deep, coming from the north-west in a little open valley between high ranges of hills. For the next two miles the valley is bounded on either side by gravel terraces, which to the north are open and covered with bunch-grass, but to the south are generally strewn over with fallen timber; the banks then begin to close in on the river and to become thickly timbered, the trail leading for a mile on a bench thirty feet above water level, through a forest of small spruce, most of which, however, are fallen. The river now turns to the north-east, and for three miles runs close to the north side of the valley, which is thickly clothed with good black pine and

poplar; to the south the hills recede, leaving a swampy flat a mile wide covered with a dense growth of spruce. The river here leaves the foot-hills, though to the south it soon comes to be again bounded by low hills on which spruce is growing to an average diameter of eighteen inches. On the north-west side it is bordered by a gravel flat, which continues to widen towards the north, till, where the stream takes a sharp bend towards the east, it opens into a wide rectangular plain bounded on the south and east by the Red Deer, on the north by Bearberry Creek, and on the west by the outer range of the foot-hills. This plain, called by the Indians Bearberry Prairie, contains about fourteen thousand acres of level alluvial land covered with a luxuriant growth of bunch-grass, and would furnish well-sheltered pasture for a large herd of cattle or horses. Opposite the south-east corner of this prairie, Fallen Timber Creek joins the Red Deer River, and for several miles west of its mouth, a plain, similar to the above but covered with scrub-birch and willow, extends on the south side of the latter stream. At the north-east corner of Bearberry Prairie, three and a half miles below the mouth of Fallen Timber Creek, Bearberry Creek joins the main river from the west. It is a small stream fifteen feet wide and eighteen inches deep, rising in the hills to the west, but for lack of time it was not followed up to its source. Below the mouth of Bearberry Creek, the Red Deer flows N. 25° E. for eight miles to the mouth of James' River, or the North Fork. The west side of the valley is occupied by shingle terraces, through which several streams, that drain the relatively high ground to the left, have cut rather deep channels. On the east of the valley a ridge rises two hundred feet above the level of the stream, its western slope being thickly overgrown with small spruce, and its top covered with marshes and spruce and poplar thickets interspersed with a few open grassy patches and small stretches of burnt timber. This ridge falls away at the end of this stretch and gives place to a broad swamp which extends for nine miles to the base of a hill called Ba-how-oo-dan by the Stoney Indians.

Bearberry Prairie.

Bearberry Creek.

James' River flows from two small lakes in a gap in the outer range of the mountains, four miles north of the Red Deer Gap, east-north-easterly and then east-south-easterly to its mouth, being, at the point where our trail crossed it, a stream fifty feet wide and two feet deep, running in a beautiful valley fifty feet deep and from a quarter to half a mile wide. The quartzite shingle forming the bottom of the valley is covered with alluvial deposit to the thickness of three feet. On the south there is a fine grove of balsam poplar.

James River.

From the mouth of James' River, the Red Deer flows N. 45° E., for twelve miles, to the crossing of the Rocky Mountain House trail, just

above the mouth of Ka-ka-koo Sipi or Raven River. The west bank is rather high, and the country stretching back from the river valley is covered with groves of small poplar interspersed with hay marshes, some spruce and pine being occasionally seen in the small valleys in which little brooks run down to the main river.

Ka-ka-koo River. The Ka-ka-koo River rises in the foot-hills between James and Clearwater rivers, and flows east-north-easterly, parallel to and a little south of the latter stream, turning east and then south-east to its mouth, where it is twenty-five feet wide and two feet deep, the lower part of its course being in a wide, open valley covered with excellent grass, and bounded on either side by wooded hills clothed with small spruce and poplar, while some few groves of pine and larch were also seen. The sides of this valley are occupied by two or three benches composed of sandy clay mixed with some quartzite pebbles, the surface being an excellent loam. Wide marshy tracts extend on both sides of the valley, and the hill to the east is called by the Crees Muskeg-wati, or "the Hill by the Swamp." This valley, doubtless, was formerly followed by the Clearwater, and its waters then ran southward to join those of the Red Deer, along a course roughly parallel with that of James and Bearberry creeks.

Red Deer River From the mouth of Ka-ka-koo River, I descended the Red Deer in a canvas canoe to the mouth of Rosebud Creek, the lower portion of this distance in the summer of 1884, and the upper portion in the summer of 1885. To the mouth of the Little Red Deer the river is winding and very swift, and is bordered alternately by scarped sandstone banks and wide gravel flats, in some cases open and grassed, in others thickly timbered with large spruce. The fall in this distance is about two hundred feet, or fifteen feet to the mile. On the east side of the mouth of the Little Red Deer there is a beautiful prairie slope, on which a little farming was done several years ago, and which has now, I believe, become the nucleus of a thriving settlement. From the mouth of this stream, the Red Deer flows east for a mile and a half, till it is joined from the north by the Ni-pa-gwa-si-mow Sipi, or Medicine River, and the worst rapid that we encountered **Bad rapid.** is in this part of its course. Below the mouth of Medicine River it becomes much deeper and has a more even current, with few rapids. It runs east for four miles, and then north-north-east for fifteen miles, until the village of Red Deer is reached. The sides of the valley are from two to three hundred feet high, scarped in places, but in places declining in a beautiful grassy slope to the water's edge. In this part, too, some islands occur covered with small poplar; and spruce as much as sixteen inches in diameter is growing under the high east bank.

At Red Deer, the Calgary-Edmonton trail crosses the river, which is here 475 feet wide. The village is situated on a beautiful alluvial plain on the east bank, behind which the east side of the valley rises in a gentle, partly wooded slope, for one hundred feet, to the level of the surrounding country. This consists of prairies covered with excellent grass, separated by groves of aspen, with a few clumps of spruce in the shallow depressions. The whole is underlain by a rich black loam, and is drained by several small creeks flowing northward. A large number of farms have been established both in the valley and on the upland, and the cultivation of wheat, oats and roots has been carried on with marked success. The west bank of the valley is here steep and scarped, with spruce in the ravines and on some of the slopes. The escarpment is sharply cut by the narrow valley of Swan Creek, which flows in from the west, draining Wapisioo Sakhahigan, or Swan Lake, which lies three miles back, occupying an area of about eight square miles and surrounded by a thick growth of poplar and willow. A mile and a half to the north-west of this lake is another three square miles in extent, called Kinapik Sakhahigan or Snake Lake.

Red Deer village. **Swan Creek and Lake.** **Snake Lake.**

From Red Deer Village to the mouth of Blind Man River, a distance, by water, of eight and a half miles, the river is very crooked, with banks one hundred and fifty feet high, abrupt and scarped on the outer sides of the bends, but on the opposite sides receding from the edge of the stream and leaving room for fine alluvial flats partly wooded with an irregular growth of poplar and willow. A small brook flowing into the river in this part of its course, drives the saw-mill which supplies lumber to the district.

At the mouth of the Blind Man, the Red Deer turns abruptly towards the south-east, and flows in that general direction for fourteen miles, cutting through the high ridge to the east of Red Deer in what is locally known as the "Cañon," in which the banks are high and steep, though not always scarped. Below the "Cañon" the valley becomes a little more open, grassy slopes extending to the water's edge on the north side, but the south side continues thickly wooded. From the end of this stretch, where a brook comes in from the south, the river flows to the east for six miles, between banks rather low and sloping; a small stream ten feet wide and six inches deep, flowing from the north, is here received. Just as the river turns again to the north-east, a thick coal seam is seen cropping out at the water's edge—the same seam that was noticed by Dr. Hector in the summer of 1858 as being on fire for some distance along the banks. When seen in 1884, though it did not appear to be burning, yet the sides of the valley in many places were covered with red and

Canyon. **Coal seam.**

yellow cinders, evidences of the combustion which had been going on at no distant date.

Blackfoot trail. From the first coal out-crop the river flows north-easterly, and then easterly for fourteen miles, to the mouth of Tail Creek, where there is a good ford at the crossing of the old Indian trail from Blackfoot Crossing to Edmonton. The banks in this distance are about two hundred feet high, and are for the most part sloping and covered with land slides which support a fair growth of spruce and poplar. From Red Deer, the river as a general rule, is swift, with numerous short rapids, and an average fall of five feet six inches to the mile.

Tail Creek. Tail Creek, which is the outlet of Buffalo Lake, is a swift stream twenty feet wide and two feet deep, flowing southward in a valley two hundred and fifty feet deep and a mile wide. The bottom of this valley, except a small area near its mouth, is of hard clay, and its sides, though bare in places, are generally clothed with poplar, interspersed with a little spruce.

On entering this valley from the west, the Red Deer immediately adopts it and turns sharply in a direction ten degrees east of south, keeping essentially the same course for twenty-four miles. The valley is from two to three hundred feet deep, and for the greater part of the above distance the river winds from side to side, leaving broad grassy

Alluvial meadows. alluvial meadows extending from the foot of the slopes which are for the most part grassed, though spruce and poplar grow in the more protected recesses. Opposite these alluvial meadows, high scarped banks rise abruptly from the water's edge, and seams of coal are often quite easily seen as black lines in the midst of strata of light-coloured clay and sandstone. At the end of this course the river turns S. 25° W. for ten miles and the valley becomes wider and much more broken, the

Bad land banks beautiful grassy meadows giving way to beds of white clay sometimes covered with a scant growth of verdure, and the sloping banks are now bare except where an occasional sage bush (*Artemisia cana*) or cactus (*Opuntia Missouriensis*) has been able to secure a hold for its roots. Immense masses of clay and sandstone have been detached from the face of the up-land, either by sliding or by erosion, and stand out in the valley as hills a hundred feet or more in height. When a shower of rain falls, it washes away any seeds that may have been dropped on these "bad-land" buttes, and at other times they are too dry to nourish any but desert plants. In the narrow ravines, however, which run into the valley from either side, some spruce and poplar is growing.

Deep straight valley. Charging its direction at the end of this stretch, the river runs S. 20° E., for twenty-three miles to the mouth of Three Hills Creek. It is three to four hundred feet wide and two to eight feet deep, with a current of two and a half miles an hour; the channel, however,

is blocked by numerous sand and gravel bars that render it very difficult to navigate, even in a small canvas canoe. The valley is moderately straight, a mile wide, and has almost perpendicular sides four hundred feet high, the general monotony of the view being broken only by groves of timber along the edge of the stream and on sheltered northern exposures.

At the mouth of Three Hills Creek the river turns more to the east; four miles lower it receives Knee Hills Creek, and twelve miles further down reaches the mouth of Rosebud Creek, where Mr. McConnell began his examination of the river in 1883 The valley retains very much the same character as before, grey clays and sandstones forming its steep sides and the "bad-land" buttes which are scattered through it, yet some good grassy flats are occasionally met with. Spruce is still seen on northern exposures and in lateral ravines, while cottonwood and willow form groves by the edge of the water. From the mouth of Tail Creek to the mouth of Rosebud Creek the river has an average fall of three feet to the mile, not taking into account its minor flexures, a current of two and a quarter miles an hour and a mean depth of water of three feet, but the channel is so much blocked by constantly shifting sand bars, that it cannot be considered in any sense navigable. However, as a means of conveying timber and lumber eastward from the wooded country along the base of the mountains, it will be of enormous value to the prairie districts on both sides of the lower part of its course. **Average fall, &c., of stream.**

COUNTRY LYING EAST OF THE RED DEER RIVER AND SOUTH OF LAT. 52°.

In this district we have a wide and, with the exception of a small area near the Hand Hills, treeless stretch of prairie, slightly undulating towards the west but much more rolling in its easterly part, and with a mean elevation of 2400 feet. In its western portion the Hand Hills rise to a height of 3550 feet, being 1350 feet above the river to the southwest and 1150 feet above the surface of the plains to the east. **Treeless plain.**

These hills consist of an elevated table land, the top of which, however, is not flat, but composed of five ridges which radiate from a centre lying to the south-east, showing a rough resemblance to the outstretched fingers of a hand, whence their name. To the north-west, west and south-west this plateau rises abruptly from the sloping plain at its base in bold escarpments five hundred feet high, and thickly wooded in some of the sheltered recesses; but to the east and south-east it slopes gradually to Egg and Little Fish lakes, which are picturesque sheets of clear water lying in the bottom of sloping valleys, the former at an elevation of 2970 and the latter of 2890 feet above sea level. A **Hand Hills.** **Egg and Little Fish Lakes.**

small stream issues from the west end of Little Fish Lake and flows through a deep, narrow valley, bounded by sandstone cliffs, to join the Red Deer a little way below the mouth of Rosebud Creek.

High ridge.

East of Egg Lake a ridge runs north and south, rising gradually from the lake, level on its top, and breaking abruptly into rolling hills on its eastern slope. Further to the south, where it runs round to the south-east of Little Fish Lake, it breaks into a mass of rolling hills, separated by numerous small freshwater pools, which in summer harbour great numbers of waterfowl. East of this ridge the country slopes gradually to the steep, though in most cases grassy hill-sides bound the wide flat valley of Bull Pound Creek to the west.

Prof. Macoun's opinion of the Hand Hills.

On the economic value of this country for farming purposes, we shall quote Prof. Macoun, who, of all those who have visited this district, is the best qualified to judge of its capabilities. "The Hand Hills district on the Red Deer River south-west from Battleford, in former years was noted for its rich pastures and for the enormous herds of buffalo wintering in its neighbourhood." "While exploring the hills in 1879, I was much impressed with the value of this region as a fine country for stock of all kinds. It may be described as a land of brooks, small lakes and ponds, grassy marshes, and rich bottoms lying between rolling or sharp, rounded hills, which are covered with nutritive grass in summer, and in winter with the samo grass, but now converted into excellent hay. Standing on a hill-top and looking over a wide area of grass-covered hills and valleys which stretched out to the horizon on every hand, and which could be extended almost indefinitely in any direction, is it too much to say that here was room for millions of cattle to roam at will and get fat on the very richest grass? No man looking over such a country could doubt its value, for were the grass of the hills to become too dry, the succulent pasture along the lake or pond was close at hand, and if that of the salt marsh was preferred, it was there also."*

Arid Plain.

Between these hills and the Red Deer River there is a sloping, arid plain covered with hard white clay washed down from the face of the escarpment, and bearing very little vegetation except sage-bush and cactus. The rainfall collects in shallow pools on the impervious soil, or is carried off in the deep gullies which lead down to the river. North of this area the country is very hilly, with a soil quite below the average. In the valleys are numbers of shallow lakes, in most of which the water is white from suspended clayey matter washed from their banks. They are fed by a few small, often sluggish, streams,

*Manitoba and the Great North-West, by John Macoun, M.A., F.L.S. Guelph, 1882. pp. 258-9.

but none have any outlet. Sullivan Lake, the largest of these, has an area of about sixty-five square miles. Its immediate banks are low, white and bare, but half a mile back from the water's edge the land rises rapidly, sometimes in a steep escarpment, while the country beyond is covered with a thick grassy sod, furnishing excellent pasture. **Sullivan Lake.**

East of the Hand Hills the land is imperfectly drained by a number of small streams flowing either southward into Red Deer River or eastward and northward into Battle River. Of these the first met with is Bull Pound Creek, which rises on the northern face of the hills, flows at first for fifteen miles in an easterly direction and then turns due south to its confluence with Red Deer River. In most of the upper part of its course it is confined in a very winding channel in the middle of an extensive mud flat three to five miles wide, bounded on either side by high grassy slopes. On this flat, which is generally wet and often impassable, the place of the grasses is largely taken by some of the species of *Equisetum*, and geese (*Anser Canadensis*) and wavys (*Anser hyperboreus*) congregate here in enormous numbers on their southward migration in the autumn. Three miles south of the eighth base line, the sides of this flat close in and form a narrow definite valley, which the creek follows for the rest of its course. The valley, whose depth averages about sixty feet, is open and grassy for the upper half of its length, but in the lower half willow is growing along the edge of the stream. **Bull Pound Creek.**

East of Bull Pound Creek, between it and Berry Creek, the country is generally undulating prairie, becoming more rolling in the northern portions, with a clay loam soil supporting short grass of excellent quality, and plenty of water is present in small pools. The soil, however, is not deep, and is underlain by stiff clay of the upper portion of the Pierre division, or derived immediately from the disintegration ration of these beds. A few clay flats are also met with, thickly covered with boulders.

Berry Creek is a small stream eight feet wide and eight inches deep, rising in several ponds east of Sullivan Lake, which at one time it probably also drained. At first it flows S. 20° E. for forty miles, receiving from the west several little tributaries in most of which there is running water only in wet seasons. In the upper twenty-seven miles of this distance it flows through wide grassy flats, though in one place in township 33, rolling hills, approaching it from either side, confine it to an ill-defined stony valley. For the next thirteen miles it winds along the bottom of a valley fifty feet deep and a quarter of a mile wide, with sloping sides of hard clay. The creek then turns and flows S. 25° W., beyond the limits of the accompanying map, in a **Berry Creek.**

wider and more sloping depression. The whole distance from its source in a straight line to its junction with Red Deer River is about eighty miles.

Beyond Berry Creek is a broad expanse of undulating or rolling prairie, underlain by good sandy soil, and usually covered with an even growth of short grass which a few years ago nourished great herds of buffalo; as late as the summer of 1884 a band of about twenty-five was seen by the writer close to the valley of Berry Creek.

Sandy ridges.

On the more level tracts, low sandy ridges are occasionally seen, often being the only elevations which break the endless monotony of the landscape. The sole drainage channel is that of Sounding Creek, which in dry seasons is, for part of its course, merely a series of disconnected saline pools. The most of the rainfall of the area collects into shallow lakes, some of which are fresh, while others are saline, with wide borders of soft white mud. In crossing the country, columns very like smoke, and as much as a hundred feet in height, are seen curling up into the air; but on nearer approach they are found to be white dust from the edge or dry beds of these "alkaline" lakes, raised by little whirlwinds which have been caused by the expansion of the atmosphere over the bare white clay heated by the glare of an unclouded sun.

White dust.

Much of this country, however, is well fitted either for cultivation or for pasture, the soil being rich and the rainfall sufficient for the growth of cereals. Prof. Macoun writes of it:—"The Great Plain, as far as known, is not arid, but produces good grass, has generally abundance of water, and usually a good soil," and "as this same region was the winter home of the buffalo, so in the near future it will be the winter home of immense herds of cattle, which can exist, as they did, by going on to the wind-swept hill tops for nutritious food, when the poorer grass of the valleys lies covered with a mantle of snow."*

Good pasture.

Sounding Creek.

Sounding Creek rises in the north-western portion of this area, though it is difficult to determine its exact source, as many flat lakes doubtless overflow into it in high water, which are quite cut off at ordinary times. At the crossing of the Lord Lorne trail, however, it has a well-defined channel, and from this point we followed it down in the early summer of 1886. At this place (on May 29th) it was merely a succession of isolated pond holes, but further to the east its valley deepens and becomes more defined, at the distance of six miles the sides being seventy feet high, with a clear cool stream of water flowing at their base. The valley, however, soon again becomes shallow and for the next twenty miles is wide with sloping sides and well defined flats through which the creek winds, while on

* Manitoba and the Great North-West, by John Macoun, pp. 102 and 104.

either hand rough hills rise to a height of one hundred and fifty feet. In a few places, small willows, gooseberry, silver-berry and currant bushes fringe the edge of the brook. Below this the stream continues to flow eastward for eleven miles, first in a narrow valley with steep clay and sandstone sides covered with sage and cactus; afterwards the banks are lower, becoming more sloping and grassy, though high ridges are seen in the distance in every direction. The creek then turns sharply to the north in a wide, flat valley, and, after a course of forty-four miles, empties, or rather leads, into Sounding Lake, for in this part of its course there was little running water, the stream having dwindled to a succession of disconnected pools occupying its channel. On both sides the land rises to a height of three hundred feet in a succession of ridges, covered with short grass, and with many boulders scattered over their summits. In the valley of a small tributary coming from the west, in lat. 52°, there is a small quantity of poplar of fair size, but otherwise the district is treeless.

Small willows.

High ridges.

District between Lat. 52° and Battle River.

This exceedingly irregular area, in its southern portion, is essentially a continuation northward of the foregoing, but clumps of willow and poplar gradually make their appearance on the northern slopes, and a little further north the surface becomes largely covered with these trees, patches of prairie constantly separating the wooded areas. Water, too, is everywhere abundant, either in lakes or small streams. In the western portion, near Buffalo Lake, fifty little lakelets were counted from the top of a low eminence.

Northern limit of plain.

This district is divided into two fairly distinct portions by a line running south from the Elbow of Battle River, the two parts differing very considerably in their physical characters.

The western portion is more or less wooded throughout, and bears as well, a strong growth of rich nutritive grasses mixed with vetch and astragalus, forming excellent pasture, and when cut making the best of hay for feed during the winter. The soil, too, is a rich sandy loam, and well suited for agriculture. Besides, even if wood were not plentiful, the land is underlain by large seams of coal, which will furnish abundance of fuel not only to those who settle in the immediate vicinity, but to others at a distance who are not so favourably situated.

Wood and grass

Coal.

Of the natural reservoirs into which the superfluous rainfall of this area is collected before being discharged into the main rivers, Buffalo Lake is the largest. According to Mr. Sullivan, Capt. Palliser's secretary, it received its present name, which is a translation of the Cree

Buffalo Lake.

name "Moostoos Sakhàhīgan," from its resemblance in contour to the outstretched hide of the buffalo, Tail Creek, by which it discharges into the Red Deer River, representing the caudal appendage. It is a beautiful body of fresh water, sixty-four square miles in extent, surrounded on all sides by high, wooded hills, that, however, in some places, recede to a considerable distance from the shore, leaving rich tracts of bottom land. On these fertile meadows, especially along the western side of the lake, the Metis had for many years a flourishing settlement, and, although they have lately almost abandoned it for other places nearer the main trails, still it is a noteworthy fact, that wherever we find any of these old settlements we are almost certain to find the richest land in the neighbourhood.

Spotted Creek. The principal feeder of this lake is Spotted Creek, which flows into it from the west after passing through Spotted Lake in the lower part of its course. It is a clear cool stream fifty feet wide and eighteen inches deep, with an easy current. Rising in the ridge to the east of Wolf Creek, it flows eastward through a wide, mostly open, valley bordered by high, wooded hills. The bottom of the valley which in places is two miles from side to side, is generally marshy in its upper part, and a number of brooks here join the main stream from the north, while in its lower portion it is a rich dry sandy loam, which would certainly yield the farmer an ample harvest.

Meeting Creek. Meeting Creek is the only other stream in this district that merits special notice here. It has its source in some small lakes, and after a south-easterly course of thirty-two miles flows into Battle River, receiving Big Knife Creek as a tributary from the south six miles above its mouth. At the crossing of the Swift Current and Edmonton trail it is a swift stream twenty feet wide and two feet deep. In the upper part of its course it flows in a sloping grassy valley the southern side of which is varied with a scattered growth of poplar, but in its lower part the sides, which are one hundred and fifty feet high, become very steep and bare, bad-land buttes similar to those on the banks of the Red Deer, standing out in the middle of the valley. On either side the country is undulating or slightly rolling, with a great deal of poplar or willow scrub, interspersed with many small shallow lakes.

East of the line drawn southward from the Elbow of Battle River, the country is much rougher than to the west, and sandy barren tracts are scattered about among its fertile portions. The only body of **Sounding Lake.** water of any size in this district is Sounding Lake, which receives Sounding Creek from the south, and is drained eastward by Eye Hill Creek into Manito Lake. Its general form is that of a horseshoe, with sides five miles long and from a mile to a mile and a half wide. The shore is of rounded sand, on which is piled in places a wall of large

gneissoid boulders. The water is slightly milky when free from weeds, and not unpleasant to the taste, but is usually green from the presence of great numbers of minute algæ, and in a high wind rolls up on the shore in opaque, pea-green waves, which make a loud roaring on the stony beach. It is on this account that the Indians have given it its present name, the fact being remarkable, as most of the lakes on the plains have clay or sand beaches, on which the water breaks with very little noise.

The lake lies in the centre of an irregular sandy flat, which is constricted in the middle by rolling hills approaching each other from the north and south, but is spread out at either end to a considerable distance beyond the present borders of the lake. To the north, an irregular mass of rolling hills stretches for ten miles, separated by chains of lakelets, the most easterly of which are saline, while the rest are fresh. The southern slopes of the hills are grassy, the northern slopes and many of the intervening depressions are covered with aspen and balsam poplar, the whole forming as beautiful a landscape of hill and valley, meadow and woodland, as can be seen in the North-west. **Wide flat.** **Wooded hills.**

South of the lake the view is cut off by a ridge of high grassy hills from two to four miles distant, through a gap in which Sounding Creek finds its way north in a wide deep valley. This ridge extends to the west as a high, rolling plateau, dotted with numerous freshwater lakes, around which a few willows are occasionally growing. The soil is a light sandy loam covered with a fine growth of short grass. Towards the west, the plateau is intersected by deep narrow gaps and, finally, by a stretch several miles wide, separating the "Nose" from the main ridge. This stretch, with the country several miles to the south, is covered with rolling grassy hills, between which lie fresh-water ponds, often fringed with poplar and willow. **High hills.** **The "Nose."**

South-west of the "Nose," which is a bare, rounded hill rising to a height of five hundred and thirty-five feet above the plain, Ribstone or Nose Creek, takes its rise, and flows northward in a narrow valley, which soon begins to be wooded with willow, poplar and maple (*Negundo aceroides*), a few moribund specimens of this latter tree having also been seen on the north side of Sounding Lake. Then, turning eastward, and cutting through a north and south ridge, it enters a broad, grassy flat, in which its edge is skirted by low woods, among which birch and maple are conspicuous. Some of the latter here measure thirty-three inches in circumference two feet from the ground, but the trees are low and branching, and not at all suited for timber. Among the shells which were found in the creek, *Anodonta Footiana* was very plentiful. **Ribstone Creek**

For eighteen miles north-eastward the valley is for the most part almost treeless and bounded to the north by broken, arid hills, while the high ground to the south is of a much more attractive character, the steep sides being often clothed with a close growth of poplar. At the end of this north-easterly course, where the stream turns to flow north, there is an extensive clay flat devoid of grass, but sparsely covered with small sage-bush and stunted cactus, among which some northern jack-rabbits, or prairie hares (*Lepus campestris*), were seen disporting themselves. It is not improbable that this species of hare ranges a little further north on the plains to the east, but this is its northern limit, as far as my observation goes.

Jack-rabbits.

Lower course of creek.

For seven miles north of the bend, the creek winds through a low marshy belt at the bottom of a wide, open, sloping valley. The wooded country then begins, and down to the mouth of the creek, though grassy stretches of considerable extent occasionally occur, timber is always within easy reach. In this distance, the bottom of the valley is often swampy, but sometimes it is hard and dry. The land on either side is sandy in many places, and especially towards the west becomes a rich sandy loam. The surface is generally rolling the hills being often clothed with medium-sized poplar, and in the depressions are many small lakes, mostly containing good water, around which the pasture is of the finest quality. Although this area on the whole is not as fertile as that to the north and west of it, yet there is here much desirable land, which, though rather sandy and not so rich as more clayey soil, still is warmer and will bring crops to maturity earlier in the year, there being thus far less danger from early frosts.

Light soil.

BATTLE RIVER.

Battle River.

Battle River is a stream from fifty to two hundred feet wide, flowing in a very tortuous channel, for the most part in the bottom of a deep and winding valley, though occasionally the brim of the channel is but little below the level of the surrounding plain. It issues from a narrow lake in lat. 52° 57′, long. 114° 9′ W., and flows in a general eastward direction across the middle of the area embraced by the accompanying map, falling into the Saskatchewan a mile and a half below Battleford, in lat. 52° 43′, long. 108° 10′ W. From the lake, for forty miles, it flows south-east in the bottom of a straight, well-defined valley, averaging half a mile in width and a hundred feet in depth, the sides of which for the first twelve miles or as far as the mouth of Pigeon Creek, are constantly wet from a number of small springs, while the flat on either side of the river is boggy and is either covered with tufts of long grass

Pigeon Creek.

or with a thick growth of spruce and tamarac. Pigeon Creek, the outlet of Pigeon Lake, is a swift clear stream thirty feet wide and one foot deep, flowing over a bed of quartzite pebbles in a narrow but rather deep valley. Below Pigeon Creek the main valley is much drier, with pleasing alluvial grassy intervales and sloping sides, mostly grassy to the north and about half wooded with small poplar to the south. In township 44, range 27, Beaver Creek, a small stream in a channel ten feet wide, flows in from the west. The country on either side of the river is, on the whole, rather poor and often stony, with many marshy tracts, though the drier parts are dotted with charming groves of aspen and willow. At the end of this south-easterly course, the Calgary-Edmonton trail crosses the stream, which is here fifty feet wide and two feet deep with an even current of two miles an hour. From the bridge it flows N. 30° E. for eight miles between low banks skirted with overhanging willows, while, a short distance back, conspicuous hills rise to a height of from a hundred to two hundred feet, though in one place the ridge to the east approaches close to the edge of the river. At the lower end of the above course the banks decline slightly, and the stream turning eastward for eleven miles flows here over a bed of quartzite pebbles and becomes much more rapid. The banks are grassy or covered with small willows, and the country on either side is beautiful grassy meadow-land interspersed with groves of poplar and underlain by a rich soil of friable clay-loam. The river then, after traversing a low willow swamp, flows into Battle River Lake, the muddy bottom of the stream here nourishing great numbers of *Unio luteolus*, *Anodonta Footiana*, and *Margaritana complanata*, the latter, judging from the number of freshly broken shells, having evidently furnished many a meal to the mink or muskrat.

Beaver Creek.

Conspicuous hills.

Fertile meadow

Battle River Lake is a shallow expansion of the river, about four square miles in area, filled with a tangled mass of weeds that come almost to the surface of the water. It serves as an excellent settling basin, for while the water flowing into it is muddy, that flowing out is clear, though dark-colored and with a very swampy taste. Its eastern shore is high and covered with a mass of large gneissoid boulders, beyond which is a gentle slope rising to the level of the surrounding partly wooded country. The western shore is low and marshy, and towards the south a prominent hill rises to a considerable height above the surface of the lake. Battle River flows out at the north-west angle of the lake, keeping a general northerly direction for six miles, the banks being at first marshy and then dry and sloping, fringed with balsam poplar and willow. After an easterly course of four miles in a channel twenty to thirty feet deep, the river again turns northward and runs through a narrow and constantly deepening valley till it is

Battle River Lake.

joined by Pipestone Creek from the west. From the lake to here the bed of the stream has been stony, or sometimes covered with large gneissoid boulders, which cause a succession of difficult rapids. The valley is wooded with poplar as well as spruce in the lower part, and the surrounding country is rich rolling land, on which there is now a flourishing settlement of half-breeds.

Pipestone Creek.

Pipestone Creek rises in the hilly and swampy country east of Pigeon Lake, and flows a little south of east to join Battle River at its easterly bend, receiving Bigstone Creek, which drains Bear Lake from the south-west, ten miles above its mouth, and Long Lake Creek from the north-west, six miles lower down. It flows in a wide valley one hundred and fifty deep at its mouth, the valley of Battle River appearing like a narrow lateral valley joining it from the south. At the mouth of Long Lake Creek the valley divides into two, the larger and main portion being occupied by Long Lake and the creek which drains it, while the united streams of the Pipestone and Bigstone wind along the bottom of the more southern and smaller branch of the valley.

At the mouth of Pipestone Creek, Battle River adopts its valley and maintains a general south-westerly direction for eighty miles, with sides throughout the distance from one to three hundred feet high, the lighter slopes being grassy and the steeper covered with poplar, spruce and birch. The river, for most of the distance, winds slowly in a very tortuous channel through alluvial flats covered with a scattered growth of willow, though at Dried Meat Lake it spreads out and fills the valley from side to side for a distance of eleven miles.

Dried Meat Lake.

Half-breed settlement.

At Salvais' Crossing, four miles above the head of this lake, there is a flourishing settlement of French half-breeds, consisting of about forty families. They are living in substantial log houses, and there is sufficient land under cultivation to raise all the field produce that can be used in the settlement. In July, 1885, wheat, barley, oats, potatoes, turnips and Indian corn were well advanced, and I was informed that for the last seven years there had been no failure of crops, seven years being the length of time that my informant had lived in that part of the country. A considerable number of horses, cattle and sheep were also seen around the houses, and all were in excellent condition.

Dried Meat Lake gradually narrows again into the river, which then meanders slowly through the bottom of a broad valley, whose sides rise gently for 300 feet from the flats ten feet above the level of the water. On the eastern side of township 43, range 18, the flats are studded with groves of ash-leaved maple (*Negundo aceroides*), many of which are a foot in diameter, and here the Indians have been accustomed to resort in spring to collect the sap and boil it down to a coarse sugar.

Maple groves.

Maple is seen in many places further down the valley, but seldom in larger or finer groves than at this point, its extreme western limit.

From the "Maples" to the Elbow, the river retains its winding character in a valley one mile wide at the top and two to three hundred feet deep. It has an average width of a hundred feet and an even current of a mile and a half an hour. The more projecting portions of the sides of the valley are very often composed of bare clay or white sandstone, while the more sloping recesses are filled with gooseberry and serviceberry bushes. Several small streams flow in from the south, draining high ground a few miles back from the river, but the north bank is unbroken by any but short lateral gullies. **Wide deep valley.**

At the Elbow, where an old trail crosses from Victoria to the plains to the south, the river turns N. 55° E., keeping this course for nineteen miles in a gradually expanding valley, the sides of which become at the same time more thickly covered with vegetation. The river is still very winding, with stretches of quiet water, separated by short rapids, in which the bottom of the channel is covered with pebbles and boulders. At the eleventh base line, the river turns sharply northward for sixteen miles to the mouth of Iron Creek, a small clear stream six feet wide and seven inches deep. The valley in this distance is wide and open, with sloping grassy banks and a bottom occupied by level well-grassed flats fifteen feet above the water, fringed with a narrow belt of poplar, maple and willow, close to the edge of the very winding stream. **Elbow of Battle River.**

Below the mouth of Iron Creek, the valley maintains very much the same character as far as the mouth of Grizzly Bear Creek, the sides being sandy and more or less sloping, sometimes well grassed or covered with timber, and sometimes almost bare, merely supporting a stunted growth of rose-bush and trailing juniper. The river is from a hundred to a hundred and fifty feet wide, sometimes very winding, and again flowing slowly over a sandy bottom in long, straight courses. In this distance it receives from the west Grattan and Buffalo Creeks, which are each about five feet wide and six inches deep. **Valley very sandy.**

At the mouth of Grizzly Bear Creek, the river turns sharply south for four miles, then east five miles, south five miles, and then a little south of east twenty miles to the crossing of the Fort Pitt trail. For this distance the valley is from 250 to 300 feet deep, with steep, grassy or partly wooded sides, and a bottom half a mile wide, intersected by old river channels, between which the flats are sometimes grassy, but usually covered with small poplar and willow.

Country Between Battle and North Saskatchewan Rivers.

"Fertile belt." Lying north of Battle River, and south of the North Saskatchewan, is the western portion of what has been known for a long time as the great "Fertile Belt," which stretches from the edge of the northern forest to the northern limit of the plains to the south. The district now under consideration consists of over 6,000,000 acres of fertile land, partly covered with groves of poplar and willow, but with everywhere, more or less extensive tracts of open country covered with luxuriant grass and herbage, ready to be used as pasture land, to furnish an abundant supply of hay for winter use, or to be broken by the plough.

In the southern portion of this district, which is drained by Battle River and the small streams that flow into it, the extent of prairie is very largely in excess of the woodland. The surface is generally undulating, and the soil is a rich sandy loam. Water is abundant in lakelets and small streams, though nowhere is there wet land that could not be readily drained. Prof. Macoun, in speaking of this country, says, *"This tract is unsurpassed in the North-West for its capacity to grow wheat, as the soil is rich, the surface is almost level, and what slope there is inclines to the south."

Soil a rich loam. Water abundant.

Of the brooks which drain the country into Battle River, Iron Creek is the most southerly. It received its name, which is merely a translation of the Cree Pī-wā-pisk-oo Sī-pī-sis, from the fact that a large mass of meteoric iron, now in the Museum of Victoria College, Cobourg, used to lie not far from its banks. Wavy Lake, of which it is the outlet, has an area of about 5,000 acres, bounded either by a hard, sandy beach, scattered over in places with pebbles of quartzite and gneiss, or by a low marshy shore. The water is good. From the south-east angle of the lake, the creek flows eastward for twenty-one miles, at first across a wide and, close to the creek, often marshy plain, and then in a valley which gradually increases to sixty feet in depth. It then turns south-eastward for sixteen miles to its mouth, its valley gradually becoming deeper and wider, till five miles above its mouth it is filled with an irregular mass of almost bare sand-hills.

Grattan Creek. North of Iron Creek, Grattan Creek has its source in a series of long, saline lakes, and after flowing S. 75° E. for fourteen miles through a deep, narrow valley, empties into Battle River. The country between these two creeks is rolling, or sometimes hilly. North-east of Grattan Creek, Buffalo and Grizzly Bear creeks rise in the rolling land a short distance south of the southern bend of Vermilion River, and flow

Buffalo and Grizzly Bear Creeks.

* Manitoba and the Great North-West, by John Macoun. p. 109.

south-eastward into Battle River, being respectively twenty-six and thirty-two miles in length. The valleys in their lower portions become deep and narrow, the south sides being generally thickly wooded while the north side is grassy or scarped.

The most easterly affluent of Battle River which comes within the area now reported on, is Blackfoot Creek, a small stream that rises in a rough and wet part of the country ten miles south of the northerly bend of Vermilion River, and flows S. 20° E. for thirty miles, to join Battle River two miles below the crossing of the fourth principal meridian. For part of its course it winds in a narrow channel through flat, open country, but in township 49 it cuts through a high ridge of hills in a deep wooded or grassy valley, and south of the crossing of the old telegraph trail its valley again becomes defined and then steadily increases in depth to its mouth. West of Blackfoot Creek, the Blackfoot Hills rise from three to four hundred feet above the level of the plain. Their contour is, however, not at all clearly marked out, and they appear more like tracts of high rolling country than as well-defined hills. Their slopes are covered with a luxuriant growth of grass, dotted with a few groves of small poplar. A few boulders are seen in places lying on their surface. Blackfoot Creek. Blackfoot Hills

North of the drainage area of Battle River, the greater part of the rainfall is collected by Vermilion River and its branches and poured into the North Saskatchewan, thirteen miles west of the fourth principal meridian. Near the same point, the western end of Grande Coulée opens into the Saskatchewan valley, while its eastern end joins the same valley thirty miles beyond the eastern limit of the map. It is a wide, generally well-defined, and in places terraced, valley, which at one time has carried the waters of the North Saskatchewan by a more southern channel than the one that the river now occupies. Grande Coulée. Terraces.

Ascending the Vermilion River from its mouth, the valley is from a quarter to half a mile wide, with sloping, mostly grassy banks, while the surrounding country is prairie underlain by moderately rich sandy loam, and dotted with groves of aspen and willow. The river is about sixty feet wide, with a bed of sand or gravel. Among the shells found on the sand bars were those of *Unio luteolus*, *Anodonta Footiana* and *Margaritana complanata*. For nine miles above where the valley turns to the west, it is exceedingly crooked, about half a mile wide and two hundred feet deep, with steeply sloping, partly wooded sides, broken by deep lateral gulleys. The upland to the south is almost open prairie, while to the north it is half wooded with small aspens, though when we passed, a fire was stripping the country of everything green, both grass and trees. For the next twenty-six miles, or as far west as Vermilion River.

Winding valley the centre of range 8, the valley continues very winding and from one to two hundred feet deep. The bed of the stream is usually a soft mud, though a few stony rapids occur at the bends, and the bottom of the valley is a stiff clay. In many places the sides rise in somewhat irregular, grassy terraces, on which travelling would be very pleasant were it not that they are often cut through by deep, narrow gulleys, which it is often impossible to cross. In ranges 5 and 6, the country back from the river is rolling, but along the brink of the valley there is a level belt covered with a luxuriant growth of grass, which was evidently at one time a favorite camping ground of the Indians, as their old lodge-poles are even yet strewed over it in great numbers. In the middle of range 8 the river flows S. 70° E. for seven miles from the mouth of Birch Creek, in a valley wider but not so deep as further east, and bounded to the north by a high range of hills from which small streams flow down in deep gulleys. Birch Creek is a small stream of clear brownish water, fifteen miles long, and near its mouth flowing in a deep, narrow gulley, but higher up it winds through the prairie in a very tortuous channel. In high water it doubtless drains Birch Lake, but when examined in August, 1886, it rose in a swampy bottom to the east of that lake. At the same time of the year, Birch Lake was a beautiful sheet of clear but slightly saline water, with very irregular outline, long, wooded or partly wooded points stretching into and almost dividing it in several places. Its shores are flat in a few places, but for the most part rise gently to a height of about a hundred feet, the south side being almost entirely open prairie, the other sides being more or less wooded with aspen or balsam poplar, always varied, however, with open glades. The beach is firm and of a coarse yellow sand.

Terraces.

Birch Creek.

Birch Lake.

Chain of Lakes. Above the mouth of Birch Creek, the valley of Vermilion River stretches for twenty-one miles N. 30° W. as far as the "Chain of Lakes," the sides being at first steep, and the southern one clothed with poplar, birch and spruce, but they soon become more sloping and rise in grassy or lightly wooded terraces to the level of the surrounding country. At the outlet of the most easterly of the lakes the river flows among huge Laurentian boulders, and falls several feet in a few hundred yards; for eighteen miles above this, it flows through low-lying marshy lakes, with soft muddy shores; in the autumn, these lakes are teeming with wild fowl. The sides of the valley continue as before to rise in long irregular slopes to the general level, or in some places even into conspicuous hills.

At the "Chain of Lakes," the definite valley that we have been describing turns more toward the north, while Vermilion River flows into it from the south. This river rises near the old telegraph line,

and flows at first northward in a slight depression on the prairie, but soon it cuts a shallow channel, which continues to deepen slightly, till at a distance of thirty-five miles from its source, the river flows from a marshy flat into the south-western lake of the "Chain." The main valley, however, continues north-westward to the Saskatchewan, and has formerly carried a very much larger stream of water than that which at present flows through it. This original stream, doubtless, occupied part of what is now the valley of the Saskatchewan, but where it entered that valley it is impossible to determine with the information at present at our disposal, though it is highly improbable that it followed its valley a the way from the mountains. Towards the east this ancient stream, instead of turning northward again towards the Saskatchewan, continued south-east through Grizzly Bear Coulée into what is now the valley of Battle River. Old valley.

North-west of the "Chain of Lakes," Egg Lake lies near the head of a small creek which flows northward into the Saskatchewan. Its water is clear and good. Its shore is well defined by a beach, at least, on the eastern side, of pebbles and small boulders, often, however, fringed with reeds for a considerable distance out into the water. Its northern and larger portion has a rounded outline, but towards the south-east, deep reedy and doubtless shallow bays, indent the shore. On the west side the country is thickly wooded, but towards the east, it is prairie, broken by small lakes and dotted with poplar groves. West of the upper part of Vermilion River, the surface is rolling, and the land is a rich clay-loam, more or less closely wooded with thickets of poplar and willow. Ascending over a low ridge we look down into a beautiful valley, the bottom occupied by Beaver Lake, which is fifteen miles long and eight and a half miles wide, and with a rather regularly oval outline. It appears, however, to be very shallow, and the water, though sweet, is generally slightly milky from suspended clayey matter. Pike certainly, and perhaps other fishes, are present in it in very considerable numbers. The shore is low with a beach of coarse quartz sand, often clayey, and sometimes blocked by a row of large boulders. To the north a rich, though treeless, prairie stretches away for several miles, while in every other direction, a wide belt of open or lightly wooded prairie slopes gently to the water, with a soil of fertile black, sandy loam, bearing a luxuriant growth of grass. Egg Lake. Beaver Lake.

Lying west of Beaver Lake and east of the Calgary-Edmonton trail, there is an apparently high and thickly wooded country which goes by the name of Amisk-wachi or Beaver Hills. Of this country very little could be learned, even from those who were living in the immediate vicinity, and it has been left as a hunting ground for the Beaver Hills.

Indians, who yearly kill a large number of moose in the deep recesses of its forests. On entering the "Hills," however, the most striking feature is the absence of the rough, hilly character which their name and reputation would lead one to expect. The country is found to be simply low ridges or sandy knolls, often thickly clothed with large balsam poplar and spruce, separated by valleys drained by numerous small streams. These streams have been everywhere dammed back by beaver, giving rise to extensive meadows, which are either impassable marshes or, since the beaver dams have been broken down, are again drained by the creeks and form beautiful wide alluvial tracts covered with long grass, from which sufficient hay could be cut to supply very large herds of cattle and horses. At present, however, there are no roads through this luxuriant wilderness, though the making them would be a very easy matter, or, at all events, access could be had to the interior in winter over the marshes themselves, which almost everywhere stretch to the verge of this low sandy plateau. The hills, too, are diversified throughout by charming lakes of clear pure water. Cooking Lake, the largest of these, is from seven to nine miles long, two and a half miles wide, and apparently quite deep. Its beach is white sand or a gravel composed of gneiss, quartzite and quartzitic sandstone ; it is often skirted with a scanty growth of rushes, and backed by a narrow grass-covered belt which rises slightly into thick woods of poplar or spruce. It is reported to contain pike and suckers, but doubtless whitefish would thrive in its waters if they were introduced. A stream twelve feet wide and a foot deep, flows south-westward from Cooking Lake into Hastings Lake, which is another body of water of considerable size, and which is drained by Swift Current or Hastings Creek eastward into Beaver Lake. There are three other principal creeks which flow from these hills, namely;—Katchemut's Creek, ten feet wide and a foot deep. An old Indian pack trail to Edmonton, which at one time was well cut out, runs up the north side of this creek. The surrounding country is generally wooded with small aspen and willow. Ross Creek, eighteen feet wide and six inches deep, rises in the northern part of the hills, and, flowing through Dry Grass Lake, empties into the north-eastern part of Beaver Lake. Deep Creek, six feet wide and one foot deep, rises in the northern part of the hills, in or south of Island Lake, and flows northward to join the Saskatchewan in the south-west corner of township 56, range 21. There are besides a number of small creeks, which drain the hills in every direction towards the surrounding lower lying country, in all of which the water is clear and good, though in the drier seasons they are often merely a succession of water holes. The hills are much more heavily wooded

Extensive meadows.

Cooking Lake.

Hastings Lake.

Katchemut's Creek.

Ross Creek.

Deep Creek.

in their northern than in their southern half, and besides balsam poplar (*Populus balsamifera*), aspen (*P. tremuloides*) and spruce (*Picea alba*), tamarac (*Larix Americana*) and birch (*Betula papyrifera*) are quite commonly met with. Some *P. tremuloides* were seen, which measured five feet in circumference three feet from the ground. Berries, too, were very abundant, the following being the most common: Service-berry (*Amelanchier alnifolia*), choke-cherry, or stone-berry (*Prunus Virginiana*), haws (*Cratægus coccinea*), eye-berry (*Rubus chamæmorus*), moose berry (*Viburnum pauciflorum*), Pembina berry (*Viburnum Lentago?*). Trees and shrubs in Beaver Hills.

South of the Beaver Hills the country is lightly rolling or level, and very much broken by large and small marshy lakes, with outlines varying considerably with the height of the water. To the west of this flat country a deep, narrow valley runs nearly north and south, at present connecting the head of a small stream that flows into Pipestone Creek with Black Mud Creek, flowing north into the Saskatchewan. These streams are quite insufficient to account for so large a valley, a valley of which that of Battle River is merely a continuation, and therefore, as in the case of the Vermilion River valley, we are forced to the conclusion that we have here one of the old drainage channels through which the Beaver Hills and surrounding country were drained southward into Battle River before the southern continental elevation diverted the rivers into more northern channels, and especially before the Saskatchewan had carved out the valley in which it now flows. Marshy country. Old valley.

DISTRICT BETWEEN THE RED DEER AND NORTH SASKATCHEWAN RIVERS AND THE CALGARY–EDMONTON TRAIL.

This district is divided very unequally by a high, wooded ridge, which runs from the banks of Clearwater River, N. 30° E. to the angle of the Saskatchewan, a short distance above Edmonton, and which causes the rain-fall to the north-west of it to flow northward into the Saskatchewan, while to the south-east the country is drained by tributaries of the Red Deer and Battle rivers.

The general character of the country, on the opposite sides of the ridge, is similar or different, according as we consider the character of the soil and the contour of the surface, or the vegetation with which it is covered. On both sides the soil is sandy, often mixed with more or less clay, and the surface is flat over considerable areas, but in places broken by high ridges of hills. On the tributaries of Red Deer and Battle rivers there are many wide stretches of prairie or of partly timbered country, and, where the woods are most continuous, the trees Character country.

are either poplar or small spruce and pine, furnishing plenty of timber for local use, but not enough to be of much value as an article of export. In the country which is drained northward into the Saskatchewan, however, there are wide marshy tracts along the banks of the streams, while beyond, on the plains and hill-sides, there is usually a thick growth of spruce, balsam and pine, often small, it is true, but much of it is very large and well suited for converting into timber or lumber. The difficulty, of course, would consist in getting the logs to the Saskatchewan. They could, doubtless, be driven on the lower portions of some of the streams in high water, while in other places roads would have to be made directly to the river, which would often necessitate the outlay of considerable capital before any large returns could be depended on.

Thick forest.

Wolf Creek.

Some of the finest trees seen were in or near the valley of Wolf Creek, a stream which rises in the watershed ridge, seven miles north of the eleventh base line, and flows N. 20° W. for thirty-three miles, joining the Saskatchewan sixteen miles below the mouth of Brazeau River, where it has a channel seventy-five feet wide and five feet deep. Near its source it flows in a shallow channel through thick forest of large spruce and balsam fir mingled with poplar, the ground, even in October, being often very swampy. Ten miles down the stream, a small creek joins it from the south-west, draining a wide, hill-surrounded valley, the bottom of which appears to be one extensive bog. For four miles below the mouth of this branch creek, the valley is narrow and wooded, and the trail that we followed kept on the side of the hill to the east, the soil here being sand or gravel covered with either small pine or windfall, a little grass generally growing among the scattered logs. Below this point, where the old pack-trail from Buck Lake to Rocky Mountain House turns up into the hills to the west, to the crossing of the twelfth base line, the valley is from two to four hundred yards wide, with pretty little alluvial meadows covered with rich pasture in the bends of the stream, bounded on either side by rough, rolling land, the most of which has formerly been well wooded, but a great many of the finest trees have been destroyed by fire. From the twelfth base line to the Saskatchewan, the creek is as yet unexamined. The water is of a brownish hue, but clear and transparent, flowing over a bed of pebbles or sand, in places scattered over with gneissoid erratics, the banks throughout appearing to be composed of glacial drift, though often the Laramie sandstones and shales must be but a short distance from the surface.

Boggy country.

Old trail.

Beavers.

In most of the streams of the West, the beavers have been so much hunted that their number is at least greatly reduced from what it formerly was, but here the number is still large, the stream being

constantly blocked up by their dams, and the large, well-kept houses in the centre of ponds close to the creek, continue to protect many an industrious family that has exacted a heavy tribute from the young poplar and willow of the surrounding woods. East of Wolf Creek, the Buck Lake trail, which was the one we followed, leads over an attractive plain dotted with small pine and poplar, and then up a willow-covered valley bounded by wooded hills. From the edge of this valley to Buck Lake, a distance of seven miles, the trail leads through a thick forest of spruce up to twenty-nine inches in diameter. **Large spruce.** With the spruce were growing balsam poplar, pine, and a few balsam fir.

Buck Lake. Buck Lake, into which several small streams flow from the high ridge to the south, is a very pretty sheet of clear blue water, surrounded on all but the south side by wooded ridges, while to the north-east two prominent hills rise sharply above the surrounding country. The beach on projecting points is of rounded quartzite and gneissoid shingle, but at least in the bays which indent its southern shore a wide marsh or moss-covered muskeg skirts the lake; beyond the muskeg stretches a thick forest of spruce. About the middle of the southern border, along a small creek, there is a fine prairie of about fifty acres in extent, covered with a close and rich growth of grass and wild pea-vine. The lake is said to contain large whitefish of particularly fine flavour, and it was from here that fish used to be supplied to the Hudson's Bay Company's post at Rocky Mountain House.

Buck Creek. From the north-east corner of the lake, Buck Creek flows northward towards the Saskatchewan, into which it empties eight miles above Goose Encampment, having there a channel eighty feet wide and four feet deep.

Other small creeks. East of Buck Creek, Strawberry, Weed, Conjuring and White Mud creeks flow northward into the Saskatchewan, with channels at their mouths from thirty to fifty feet wide. Most of the country drained by these streams is either thickly wooded or swampy, but towards the east it becomes much more open, and around the head of Conjuring Creek and along the banks of the White Mud there are some rich grassy prairies, behind which, on the latter stream, there is swampy land thickly wooded with spruce and poplar.

Pigeon Lake. Crossing a high ridge at the head of Weed Creek, on the trail from Edmonton to the old Methodist mission of Woodville, we descend one hundred and thirty feet to Pigeon Lake, the level of which is eighty feet above the country two and a half miles to the north. The lake itself is ten miles long and four miles wide. The water is clear and blue, and contains excellent whitefish and pike. Its outline is rather regular, with high banks, which in all directions but the south-east

rise to hills, one to three hundred feet above its level, thickly clothed with poplar or spruce, though in places near the lake there are a few small clearings, on which comfortable little shanties have been built, and around which some land has been tilled, and is reported to have borne good crops both of roots and cereals.

Battle Lake.

Continuing southward and crossing another high ridge, we descend into a long, narrow valley, in the bottom of which lies Battle Lake, a sheet of clear blue water, five miles long and half a mile wide, and said to contain a great number of whitefish. The beach is usually a firm grey sand, fringed by a narrow margin of rushes, and the middle of the lake appears to be very deep. The south shore rises gradually to a ridge four hundred feet high, thickly clothed with poplar and spruce; the north shore is one hundred and thirty feet high, and covered either with luxuriant grass or with small groves of poplar. At the west end of the lake, on this side, a prominent hill rises to almost as great a height as the ridge to the south, and on it, besides spruce and poplar, some pine (*P. Murrayana*) is growing, while in the valley below is a small grove of tamarac. The valley continues beyond the lake towards the north-west, representing another old drainage channel, in which there is now a watershed.

Bear Lake.

To the east of these two last mentioned lakes, the country is very swampy and rather thickly covered with poplar and willow till Bear Lake is reached. This lake, which is drained north-eastward into Battle River by Bigstone Creek, resembles an extensive marsh with watery centre, surrounded by rather low, rolling and partly wooded hills, which, however, rise a little higher towards the south than in any other direction, and are known as the Bear Hills. East of Bear Lake, a fertile plain stretches away to the banks of Battle River, on which an industrious band of Indians have settled, and now have a considerable area of land under cultivation.

High wooded ridge.

From the east end of Battle Lake, there is a well cut out pack-trail, running south-westward for six miles, at first over a high ridge, thickly wooded with spruce, birch, poplar and some pine, and then across a sandy slope, sparsely covered with small pine, to a wide valley similar to that of Battle River. Its sides are from a hundred to two hundred and fifty feet high, sloping, and very much encumbered with burnt and fallen trees. Its bottom is covered with a mossy bog from a quarter to half a mile wide. At the point where the trail reaches it from the north-east, the valley is drained southward by Blind Man River, but on following it for six miles N. 30° W. we come to a small stream flowing in an opposite direction, finding its way into some of the creeks that flow northward into the Saskatchewan.

Blind Man River.

A short distance south of the twelfth base line, while the bottom of the valley still continues boggy, its western side consists of a sloping prairie stretching back for two or three miles to a ridge of hills, and for five miles down the river. This prairie, covered with luxuriant grass, is watered by several small streams with gravelly beds, and here and there a few dead trunks of pines and spruces are standing, the only remains of the forest which has long ago been destroyed by fire. At one place in the bed of a small stream, this prairie was seen to be underlain by four feet of yellowish sandy loam, beneath which is a bed, twenty feet thick, of small pebbles. South of this plain is an old channel of the river, of a depth varying from one to two hundred feet, and, with a very miry bottom, while the river itself flows a mile and a half still further south in a wide valley, and then turns sharply westward for five miles through a high ridge in a deep-cut, narrow and wooded valley before it joins its waters with those of the West Branch.

Along the southern bank of this portion of the river is a well worn pack-trail, which crosses the main stream just below the junction of the two branches, and then continues over the hill to the west. It, doubtless, leads from the Stoney reserve at Wolf Creek into the forests and hunting grounds around Buck Lake.

The west branch of Blind Man River is formed by the union of numerous small streams that rise on the face of a high, wooded ridge four miles north of the twelfth base line, and after crossing that line, flows in a general south-easterly direction for ten miles to its junction with the main stream, through a wide, sloping valley, the bottom of which is generally open, sometimes swampy, and at other times dry and sandy. Six miles below the base line, a stream six feet wide and a foot deep, flows in from the west, draining a wide, sloping valley lying among the hills in that direction. Below the confluence of the two branches, the river continues in the same valley for two miles and a half, and then, although the valley continues on, it leaves it and cuts a narrow gorge through the high ridge to the west, till it reaches another similar wide valley a little further west, down which a small stream is flowing. The sides of this valley are more or less thickly wooded with poplar and spruce, while its bottom is mostly open or covered with small willow scrub. Four miles below the point where the river enters this valley, a small stream joins it from the east, flowing down the valley that the river had left eight miles higher up. For the next ten miles, or to the mouth of Gull Creek, the valley retains very much the same character, the soil being a rich sandy loam covered with a close coating of long grass. The river runs in a winding channel forty feet wide and ten to

West Branch.

Gull Creek.

twenty feet below the level of the flat. The water is of a light brown colour, and with a slightly marshy taste. Gull Creek joins Blind Man River two miles below the crossing of the eleventh base line. It is five feet wide and a foot deep, with a muddy bed, and flows in a narrow valley thirty-five feet deep. It drains Ki-as-koos Sa-kha-higan, or

Gull Lake. Gull Lake, which lies three miles to the east. This is a body of clear blue fresh water, eleven miles long and four miles wide, with contour more or less regularly rounded. Its beach is a firm sand or gravel, and on the western side the shore rises quickly into a high, wooded ridge, while to the south and east the beach is skirted by a row of large balsam poplars, behind which is a marsh covered for several hundred yards with grass or willows, beyond which a grassy or partly wooded slope rises to the edge of the thicker timber with which the higher lands are covered.

Below the mouth of Gull Creek, the river continues nearly southward for four miles to a short distance beyond the crossing of the old cart-trail from Edmonton to Rocky Mountain House. The channel here is from twenty to thirty feet deep, but the valley is marked only by wide slopes stretching towards the east and west. That to the west is grassy or only lightly wooded with small willow or poplar, and extends for six miles around the south end of the high ridge which has been bounding the valley of the river to the foot of the Medicine

Medicine Lodge Hills. Lodge Hills. These constitute a partly wooded ridge rising 675 feet above the river. At the south-eastern corner of this prairie, the river turns eastward and flows for fourteen miles through a deep, narrow valley to join the Red Deer where this latter stream turns sharply eastward through a high ridge in what is locally known as the Cañon.

Medicine River Travelling along the trail westward from Blind Man River, through a narrow gap in the Medicine Lodge Hills, we reach a wide, shallow valley which is drained southward into the Red Deer by Medicine River. This stream which is said to issue from a lake near the twelfth base line, flows southward, and crosses the eleventh base line in range 4, west of the fifth principal meridian. At this point it is a stream fifty feet wide and two feet deep, flowing over a bed of soft mud, with occasional pebbly bars. The water is rather dark brown, and has a decidedly swampy taste. In it are found a great number of fresh-water mussels (*Unio luteolus*), from which circumstance the Stoney Indians have called it the Mussel River. North of the eleventh base line, the main stream appears to flow in the centre of a wide, partly wooded and probably swampy plain, while a small branch flows in from the west,

West branch. draining the face of a high range of wooded hills, though here too a narrow belt of boggy land follows the edge of the stream. For five and a half miles south of the base line to the crossing of

the Rocky Mountain House cart trail, the banks of the river are from thirty to fifty feet high, and generally grassy, while the surrounding country is rolling, and either grassy or covered with groves of poplar. For six miles south of the cart trail crossing, the country continues of much the same character till the mouth of Horse Pound Creek is reached, which is a stream about half the size of Medicine River, draining a considerable, though at present ill-defined, extent of country east of Raven and Clearwater rivers. Several of its branches, which are crossed by the above-mentioned cart trail, flow through more or less deep, narrow valleys across wide plains, which are generally lightly covered with dwarf birch or willow. Below the mouth of this creek, the valley gradually spreads out till it becomes a wide shallow depression bounded by low, sloping hills, lightly clothed with poplar and willow. The land here is generally covered with dwarf willow, on a rich loamy soil. The river flows in a very winding channel between low, grassy banks, varied here and there by the presence of a few groves of spruce or willow. Traces of beaver are plentiful, old houses and dams being seen wherever there has been sufficient wood to supply them with food and building timber.

Horse Pound Creek.

Fertile slopes and bottom land.

Saskatchewan River and some of its Tributaries.

The Clearwater River rises in one of the inner ranges of the Rocky Mountains, in about lat. 51° 40′, long. 116° 15′, close to the headwaters of Pipestone Creek, which flows south-westward into the Bow River, while the Clearwater River takes a course to the north-east, leaving the mountains in lat. 51° 57′, long. 115° 42′, and eventually emptying into the North Saskatchewan a short distance below Rocky Mountain House. Through the foot-hills, and as far east as the main pack-trail, north from Morley, the banks of the river are reported to be thickly wooded. At the crossing of this trail, the south bank is steep and thickly wooded with spruce and poplar, while the northern side stretches back for about a mile as a wide grassy flat with a few small pine and poplar scattered over it. This flat is one of the famous camping grounds of the Stoney Indians. It stretches for about four miles along the north side of the river, where it is cut off by a bend in the stream. The north side below this is thickly wooded or swampy, the height of the bank decreasing to about thirty feet, while on the south side a flat half a mile to a mile wide, and grassy or covered with very low willow scrub, forms the bottom of the valley. This side of the valley gradually lowers, and then rises abruptly in a hill 150 feet high, beyond which a wide flat stretches for a considerable distance to the

Clearwater River.

Wide alluvial plain.

south, and is bounded on the east by Swampy Hill (Muskeg-wati, in Cree), along the foot of which a small spring creek (As-kow-ĭ Sĭ-pĭ-su) flows northward into the river. The old Blackfoot bridle-trail follows this prairie stretch along the south side of the river, and at the mouth of this creek joins the cart-trail to Rocky Mountain House.

Wooded valley. Below the mouth of Askowi Creek, the Clearwater turns to the north-west, flowing in a valley for the most part wooded with spruce, while the higher ground to the east is either open and grassy or presents scattered groves of poplar and sometimes also of pine. The river then turns more to the north, and after a further course of eight miles flows into the Saskatchewan, receiving Prairie Creek as a tributary from the west about two and a half miles above its mouth. Opposite the mouth of Prairie Creek is a beautiful grassy meadow, backed by rolling, sandy ridges and fringed along the water's edge by a row of fine poplars.

The Clearwater, at its mouth, is a swift clear stream, one hundred and fifty feet wide and fifteen inches to two feet deep, flowing over a bed of rounded quartzite pebbles. Higher up, the channel is, in many places, divided by numerous wide gravel bars, over which the river, in high water, spreads as a wide, shallow torrent.

Prairie Creek. Prairie Creek is a beautiful swift stream of clear water, fifty feet wide and nine inches to one foot deep. It rises in the foot-hills north of Clearwater River, and flows eastward to a short distance beyond the Stoney pack-trail, where it turns north for ten miles before emptying into the Clearwater. In this lower portion, which was the only part traversed, it runs in an irregular valley twenty to fifty feet deep, sometimes as much as a quarter of a mile wide with open prairie flats in the bends, and sometimes wooded to the edge of the water. Beaver dams block the streams in many places.

Country between Clearwater River and Prairie Creek. Between these streams the country is made up, to a considerable extent, of ridges of yellow sand, having a general north-westerly and south-easterly trend, broken through in many places so as to form isolated hills and separated by marshy ground, in the centre of which the water collects in small lakes or flows in little streams northward into Prairie Creek. These sandy ridges have at one time borne a fine forest of tall straight pine (*P. Murrayana*) from ten to twenty inches in diameter, but all the trees have been killed by fire, and the trunks alone are now standing, covering the ground like a gigantic stubble, while here and there a few small poplar relieve with their green foliage, the dead and wintry appearance of the landscape.

Saskatchewan River. The North Saskatchewan rises in numerous streams, which flow from the watershed range of the Rocky Mountains, many of which streams are fed by glaciers of considerable size. Flowing in a general

way to the east of north, it leaves the main range of the mountains in lat. 52° 14′, long. 116° 25′ W., and, after a course of from sixty to seventy miles eastward, is joined by Clearwater River, just below old Rocky Mountain House, from which point we descended it in a boat to Fort Pitt.

Rocky Mountain House, the ruins of an old fort of the Hudson's Bay Company, is situated on an alluvial grassy flat bounded on the south and east by the river and on the north and west by dense forests and swamps. On the south side of the Saskatchewan a similar flat extends for a mile up the Clearwater, though here it is dotted with groves of poplar and willow scrub. The elevation of these flats above the sea was barometrically determined at 3,125 feet. Of the climate we know very little, as the place has been deserted for a number of years, but Dr. Hector, who was there in January 1858, refers to it as follows:*—"Sometimes before abandoning the fort in the spring, the Company's servants have planted potatoes and sown barley and turnips, and what was left by the Indians of the resulting crop until their return in the autumn, was sufficient to prove that the soil and climate are very favourable to agriculture. Every day we had here soft winds from the west, which cause a rise in the thermometer, sometimes to even above the freezing point, and the winter is said to be always much milder and the spring earlier than at places further to the eastward." **Rocky Mountain House.**

Opposite the old fort the river is four hundred feet wide, with a still wider bed of quartzite gravel. The water, flowing from glaciers, has quite a milky appearance, while in the Clearwater it is pure and transparent.

At the mouth of this latter stream, the river makes a sharp bend to the north and flows N. 13° W. for forty-nine miles measured in a straight line. The river in this stretch is swift, and when seen in September had a current of from four and a half to five miles an hour, with a fall of eight feet to the mile, the channel being obstructed by islands and bars of quartzite gravel. For a full description, however, of the valley from Rocky Mountain House to Edmonton, we must refer to subsequent pages of this report.

Edmonton is a thriving town of about nine hundred inhabitants, situated on the north bank of the Saskatchewan, and about two hundred feet above its high-water level. Located as it is, as far up the river as steamboats can depend on being able to reach during the greater part of the season, it has for many years been a chief distributing point for the supply of the Hudson's Bay Company's posts throughout the wide region to the north-west drained by the Mac- **Edmonton.**

*Journals, &c., relating to the Exploration by Captain Palliser, London, 1863, p. 76.

kenzie River into the Arctic Ocean, and the northern furs are now sent east from there either by boat down the river to Winnipeg or by trail to the Canadian Pacific Railway at Calgary. This trail has recently been surveyed and marked by the Dominion Government; most of the streams crossing it are bridged, and there is a good ferry across Red Deer River; consequently, in fine weather—and for the greater part of the year the weather in that part of the country is fine—it is an excellent highway. Edmonton has also direct telegraphic communication with the east by a line on the old location of the Canadian Pacific Railway, as well as by a line just completed through the more settled country on the north side of the river. A plentiful supply of wood can always be obtained from points higher up the Saskatchewan, but it is not necessary to use wood for fuel, the quantity of coal close at hand being inexhaustible. Mr. Donald Ross has run a drift into the side of the bank immediately below the main street of the town, and is mining a coal of good quality, which, when protected from the weather, will keep for a considerable time, and burns well both in closed stoves and in open grates. Judging by analyses it is equal to much of the coal which is now being so largely mined in Colorado, and superior to that mined at Almy, in Wyoming Territory, where the total output for 1883 is stated at 219,351 tons.*

Coal.

Very fertile district.

Besides its other advantages, Edmonton is in the centre of a district of great fertility, the soil being a rich, deep, black loam that will bear heavy crops of all the ordinary cereals and roots. For these products there is at present a good local market, but should the supply exceed the demand, the farmer could always utilize the surplus in feeding his horses, cattle and pigs, and thus avoid the loss more or less incidental to a purely ranching district.

Fort Saskatchewan.

Below Edmonton, the river flows N. 45° E. for fifty-two miles in a valley from one hundred and fifty to two hundred and fifty feet deep, with sloping, partly wooded, or sometimes scarped sides. In the bottom are wide alluvial intervales, some of which are occupied and tilled, while others are waiting for the settler. On one of the largest of these, the headquarters of Clover Bar settlement is situated, behind which lie a number of well-tilled farms. Twenty-five miles, by river, below Edmonton, is Fort Saskatchewan, where the high banks recede from the river, leaving a beautiful open bench on either side. On the south side, the Mounted Police barracks are situated, while, on the north side, there is a flourishing settlement, with good, comfortable houses and well-cultivated fields. This is the place selected to bridge the Saskatchewan, on the amended location of the old Canadian

* Mineral Resources of the United States, 1883 and 1884, by Albert Williams. Washington, Government, 1885.

Pacific Railway, before the location was moved still further to the south,* and, certainly, there are few, if any, places between Rocky Mountain House and Fort Pitt, where the river is so accessible and easily crossed.

Near the mouth of Hollow Hill Creek, the river turns and flows eastward for twenty-five miles to the mouth of White Earth Creek. The southern bank is generally high and thickly wooded, while the north side is partly open and slopes gently to the river. There are a few houses to be seen on this slope, a short distance back from the stream, and around them a small area of land is under cultivation. About the middle of the above stretch is situated the Hudson's Bay Company's old post fort of Victoria, now abandoned by the Company, but still occupied by an Indian agent and also a missionary of the Methodist Church. At the mouth of White Earth River, which is the most northerly point reached by the Saskatchewan, the river turns and flows a little south of east for one hundred and twenty-one miles to Fort Pitt. The sides of the valley, in this distance, are high and sloping, sometimes open, but generally lightly wooded, and often thickly clothed with berry bushes. **Victoria.**

The following poetical description of this part of the river is given by Gabriel Franchère, who in 1814 descended it from Fort George, on his way from the west coast to Montreal:—

Description of the river by G. Franchère.

"The River Saskatchawine flows over a bed composed of sand and marl, which contributes not a little to diminish the purity and transparency of its waters, which, like those of the Missouri, are turbid and whitish. Except for that, it is one of the prettiest rivers in the world. The banks are perfectly charming, and offer in many places a scene the fairest, the most smiling, and the best diversified that can be seen or imagined: hills in varied forms, crowned with superb groves; valleys agreeably embrowned, at evening and morning by the prolonged shadow of the hills, and of the woods which adorn them; herds of light-limbed antelopes, and heavy colossal buffalo—the former bounding along the slopes of the hills, the latter trampling, under their heavy feet the verdure of the plains; all these champaign beauties reflected and doubled, as it were, by the waters of the river; the melodious and varied song of a thousand birds, perched on the treetops; the refreshing breath of the zephyrs; the serenity of the sky; the purity and salubrity of the air; all, in a word, pours contentment and joy into the soul of the enchanted spectator. It is above all in the morning when the sun is rising, and in the evening, when it is setting, that the spectacle is really ravishing. I could not detach my regards from that superb picture, till the nascent obscurity had obli-

* See Report and Documents in reference to the Canadian Pacific Railway, 1880, pp. 24 and 69.

terated its perfection. Then, to the sweet pleasure that I tasted, succeeded a *triste*, not to say a sombre melancholy. How comes it to pass, I said to myself, that so beautiful a country is not inhabited by human creatures? The songs, the hymns, the prayers of the labourer and the artisan, shall they never be heard in these fine plains? Wherefore, while in Europe, and above all in England, so many thousands of men do not possess as their own an inch of ground, and cultivate the soil of their country for proprietors who scarcely leave them whereon to support existence; wherefore do so many millions of acres, of apparently fat and fertile land, remain uncultivated and absolutely useless? Or at least, why do they support only herds of wild animals? Will men always love better to vegetate all their lives on an ungrateful soil, than to seek afar fertile regions, in order to pass in peace and plenty, at least the last portion of their days?" *

DESCRIPTIVE GEOLOGY.

List of formations.

The rocks that will be considered in this report exclusive of those that have been deposited in glacial times, are referable to the following formations, a full account of which will be found in the chapter on Systematic Geology:—

Tertiary and Cretaceous.
- Miocene,
- Laramie, { Paskapoo beds, Edmonton beds,
- Fox Hill and Pierre,
- Belly River,

Tributaries of Bow River.

Eastward from the edge of the disturbed region of the foot-hills, the Bow River and its tributaries drain an area of about four hundred and thirty square miles within the district covered by this report, the tributaries being three small streams which join the main river from the north. Cochrane Creek, the most westerly of these, has a length of about eleven miles, and in low water it averages eight feet wide, and it is eighteen inches deep. In its upper part it flows in a sloping grassy valley which, however, soon becomes deep and narrow, and near its mouth it is wooded with small poplars. No rock was seen in the valley near the crossings of either the Morley-Calgary or the Morley-Edmonton trails.

Cochrane Creek

*Narrative of a Voyage to the North-West Coast of America. By Gabriel Franchère. English translation. New York, 1854, pp. 321-324.

Big Hill Creek, the next stream to the eastward, carries a little more water than the last, and is about five miles longer, and like it abounds with fine speckled trout. In the upper part of its course it flows southward in an open sloping valley, but soon turns south-westward and flows in a valley a quarter of a mile wide and from two to four hundred feet deep, till it passes the west end of the "Big Hill." In the sides, hard brownish-grey, massive and thin-bedded sandstones crop out with a light dip towards the west, indicating the east side of a low synclinal which here skirts the edge of the foot-hills before the rocks assume the practically horizontal position which they occupy on the plains. Big Hill Creek. Sandstone.

Nose Creek flows in a wide flat valley, along the sides of which, in its lower portion, hard grey false-bedded sandstone crops out, being a continuation of the beds which are exposed near the mouth of the Elbow River, and which clearly belong to the upper portion of the Laramie. At Shaganappi Point, a short distance above Calgary, where essentially the same beds may be seen, Sir J. W. Dawson collected and determined the following species of fossil plants:—*Platanus nobilis*, *P. Raynoldsii*, *Populus genetrix*, *P. acerifolia*, *Sassafras Burpeanum*, *Viburnum asperum*, *V. Calgarianum*, *V. oxycoccoides*.* Nose Creek. Fossils in rocks of Paskapoo series.

On Bow River, opposite the mouth of Fish Creek, in sandstones of the same, or perhaps of slightly greater age, along with *Sequoia Nordenskioldii*, *Platanus nobilis* and *P. Haydenii*, numerous specimens of *Unio Danæ* (?), *Viviparus Leai*, *Thaumastus limnæiformis* and *Campeloma producta* were found, all of which are common further north in strata ranging from the top of the Edmonton beds to a considerable height in the upper Laramie or Paskapoo beds, which latter name is used as designating all the sandstones and sandy shales of the Laramie newer than the Edmonton or brackish water beds at the base of this formation, and hence as representing not only the Porcupine Hills series of Dr. G. M. Dawson, but also his Willow Creek series, and all but the lowest six hundred feet of his St. Mary's River series, it having been found impossible to trace out or define these three divisions in this section of the country.

Red Deer River and its Tributaries.

The Red Deer River rises in one of the interior ranges of the Rocky Mountains, and, flowing eastward, joins the South Saskatchewan near the fourth principal meridian, receiving in the upper part of its course especially, a number of beautiful clear streams, Red Deer.

* On the Fossil Plants of the Laramie Formation of Canada, by Sir J. W. Dawson, Trans. Royal Soc. Can., Vol. IV., Sec. 4, pp. 21-29.

which rise either in the mountains themselves or in the foot-hills which skirt their eastern border. After emerging from these hills, at an elevation of 4000 feet above the sea, and flowing four miles along the edge of Bearberry Plain, a wooded ridge stretches south from the river, showing close to the water's edge a low escarpment of rather hard, coarse-grained grey sandstone, with an intercalated band of dark sandy shale, dipping N. 73° E. $< 15°$. These sandstones and shales, as far down the river as the outcrop of the twelve-feet coal seam, all belong to the Paskapoo subdivision of the Laramie, so that for that distance it will be necessary merely to notice the general character of the beds. Below the last mentioned point, and as far as the mouth of Fallen Timber Creek, the flats which stretch along either side of the river are underlain by a bed of quartzite pebbles, which have been carried down by the stream from the mountains, and scattered over the bottom of the valley; this bed is covered by a thin deposit of alluvial soil, which now bears a rich growth of grass. Below the mouth of Fallen Timber Creek, for three miles, no rock exposures were seen, the eastern bank being high and wooded, the western, flat and grassy.

Quartzite pebbles.

The river for the next seventeen miles was not visited by me, but Dr. Hector reports the banks wooded, with shingle terraces up to two hundred and fifty feet above the river.

A short distance above the mouth of Raven River, on the south-east bank, there are several exposures of light-grey, coarse-grained, irregularly-bedded sandstone, in which were found leaves of *Catalpa crassifolia*, and of a species of *Juglans*. Just below the mouth of Raven River, and for three miles along the north side of the river, scarped banks are seen, showing sections, of which the following may be taken as typical, though in the western parts the sandstone largely takes the place of the upper beds:

Section near Raven River.

	FEET.
Light-coloured, roughly-stratified boulder-clay with numerous boulders	5
Stratified sand becoming slightly clayey at the top, and containing a few pebbles	7
Rather hard, dark-coloured, unstratified boulder-clay, containing pebbles, none of which are Laurentian, some being fragments of coal. The line between these beds and the preceding is very sharp	17
Bed of quartzite pebbles, with soft sandy matrix. The pebbles are lying flat, but there is no other evidence of stratification	20
Olive sandy shales and beds of clayey sandstone, with some nodular clay-ironstone, lying almost horizontal or with a slight westerly dip	8
	57

In these sandstones and shales at the bend to the east, fragments of a *Unio* and some univalve shells were found. Along the river for nine miles to the mouth of the Little Red Deer, scarped banks are seen at almost all the convex bends, composed of hardish grey, often false-bedded sandstone, interbedded with olive sandy shales, and in some places with thin beds of marl, made up of the remains of fresh-water shells, among which *Physa Copei*, *Unio*, and *Viviparus* were recognized. The bed of pebbles mentioned in the last section is also occasionally seen overlying the sandstone and shale. East of the mouth of the Little Red Deer, is a beautiful flat prairie, underlain with a bed of shingle similar to that forming Bearberry Prairie at the mouth of Fallen Timber Creek. Below the mouth of Medicine River, an exposure of horizontal grey sandstone again occurs on each side of the river, and then the banks fall away till the northerly bend is reached, when they again become high and scarped for a short distance. The beds for thirty feet above the water are coarse sandstones and shales, above which there is a thin band of lignite, and then, again, sandstones and shales pierced by what, no doubt, have been roots of trees, and containing numerous fragments of fossil leaves, among which *Sequoia Nordenskioldii* and *Viburnum asperum* were recognized. Beyond this, the banks are mostly sloping, grassy on the west side and wooded on the east; the stream is not rapid as before, and is obstructed here and there with wooded islands. **Fossils.**

A short distance below the crossing of the Edmonton-Calgary trail, on the west side of the river, there is a considerable exposure of Paskapoo sandstone and shale, overlain by the pebble bed and lower boulder-clay. Above the latter, is a bed ten feet thick of light-coloured hard stratified clay, in some cases almost shaly, forming a projecting ledge along the top of the bank. The lower boulder-clay is here eighteen feet in thickness, and is intersected by numerous jointage planes, which cause its exposed surfaces to weather in columnar or prismatic shapes. It is composed of hard dark-coloured sandy clay, containing a few pebbles mostly of light-coloured quartzite, though some of gneiss were also observed, and there are also scattered through the matrix a large number of small angular fragments of coal, to the presence of which the prevailing dark colour of these beds is due. **Paskapoo sandstone.** **Lower boulder clay.**

In the sandstone at the foot of this bank, limestone nodules were found, in which are included remains of *Goniobasis tenuicarinata* and *Hydrobia*, sp. These limestone nodules were examined by Mr. Hoffmann of this survey, and were found by him to yield, when burnt, a very good lime. **Limestone nodules.**

Below this, to the mouth of the Blind Man River, the banks are composed of horizontal light-grey sandstones, and grey and olive

shales, and in almost all the escarpments, fragments of fossil shells were found. At a mile, measured in a straight line, above the mouth of Blind Man River, there is a scarped bank showing forty feet of sandstone and shale. Near the top, and under a thick band of hard sandstone, is a thin dark shaly band, containing fossils. About five feet below it is a two-inch seam of coal, and close to the water's edge, there is a bed of marlite from one to three inches thick, made up of fragments of fresh water shells, among which *Viviparus Leai* and a *Unio* were detected, as well as some fragments of the jaws and other parts of fishes. At the mouth of the Blind Man River, the following section is seen:—

Mouth of Blind Man River.

	FEET.	INCHES.
Thick-bedded sandstone	10	0
Olive shale	15	0
Hard flinty sandstone	0	3
Coal	0	1
Sandstone and shale	3	0
Carbonaceous shale	0	8
Grey sandstone (to water's edge)	3	0
	52	0

For twenty-one miles below the mouth of Blind Man River, the Red Deer flows in a deep valley, with beautiful alluvial intervales, the sides gradually becoming lower and more sloping. but they are occasionally scarped and then show coarse-grained sandstone, and light-coloured sandy shale, dipping slightly towards the west.

Coal.

About the middle of range 24, a seam of coal is seen cropping out at the water's edge, overlain by a bed of soft, coarse-grained, light-coloured sandstone, in which some silicified wood is included. A quarter of a mile further down the river, the same seam is seen, showing the following section:—

	FEET.	INCHES.
Coal	5	0½
Carbonaceous sandstone	0	4
Carbonaceous shale	1	7
Coal	1	3
Shale	0	10
Coal	2	0
Shale	0	2
Coal	1	4
Clay	0	2
Coal	0	6
Clay	0	1
Total	13	3½
Total Coal	10	1½

This seam occupies the same geological position as the Big Coal Seam on the Saskatchewan River further north, namely, the top of the clays and sandstones of the Edmonton subdivision of the Laramie, and it is not improbable that it is a continuation of the same seam. Its extension to the north will be considered later on in this report.

The seam is underlain by a soft coarse-grained sandstone containing an irregular seam of clay-ironstone one foot thick; and all the way to the mouth of Tail Creek, a distance of eighteen miles, similar sandstones, with a light dip westward, crop out at the outer side of the curves of the river. The banks are generally grassy or wooded, and the above mentioned coal seam gradually rises to the top of the bank, its presence being indicated, in many places, by red ashes and cinders, while other seams, of very small thickness, are exposed under it. In the valley of Tail Creek, the whitish clayey sandstones of the Edmonton series are occasionally exposed, and all along the valley of the Red Deer as far as the mouth of Rosebud Creek, excellent sections of these rocks can constantly be obtained. Two miles below the mouth of Tail Creek, on the east side of the river, the bank is three hundred feet high, and is composed of grey and olive sandy shale and clayey sandstone, with some thin seams of coal- Two hundred feet from the top there is a layer of ironstone nodules, containing numerous fragmentary impressions of leaves, among which *Trapa borealis* and a species of *Salisburia* were recognizable. A short distance lower down on the opposite side of the valley, there is a cut-bank of similar shale and sandstone, showing an irregular seam of coal, and two miles further down on the west side, is a cliff largely composed of sandy shale, but a coal seam is exposed thirty feet above the water, which shows the following section :—

Edmonton series.

Fossil leaves.

Coal.

	FEET.	INCHES.
Coal	0	3
Dark sandy clay	0	2
Coal	1	1
Dark sandy shale	1	6
Coal	2	4
Plastic clay shales	0	4½
Coal	0	11
Dark sandy shale	4	7
Coal	1	9
Grey sandy shale	1	5
Coal	1	2
Sandy shale	0	3
Coal	3	0
Total	18	9½
Total of Coal	10	6

Analysis.

Specimens of the lower part of this seam have been analysed by fast coking, by Mr. Hoffmann, with the following results:—

Hygroscopic water	10·02
Volatile combustible water	32·11
Fixed carbon	45·19
Ash	12·68
	100·00

Coke, non-coherent.

Petroleum claims.

Between these two last mentioned escarpments, but on the opposite side of the river, several claims have been taken up by gentlemen who were under the impression that petroleum was to be found here, and it has even been asserted that it is to be seen covering the river for a considerable distance below this point. In two separate examinations in the early summer and in the autumn, I could not discover any traces of petroleum, and Mr. Hoffmann examined in the laboratory of the Survey, but with no better success, specimens of clay and sandstone, which were brought tightly sealed from some of the claims. On one of these there is a spring trickling out of the bank and where the water reaches the flat several small pools are formed which dry up in the autumn, leaving a glistening black deposit, which looks something like gum, and which forms, when shaken up in water, a rich brown sepia-like pigment. In the bank is a seam of lignite, and the black gum-like substance is composed of the fine soft clay which occurs in thin seams with the lignite, and which is stained by a brown colouring matter that has been dissolved out of the lignite by the water of the spring flowing through it.

For seventeen miles down the river light-coloured sandstone, with included thin seams of coal, is seen, at intervals, overlain by light-coloured boulder-clay. Where the stream turns to the south-west, bad-land buttes begin to stand out in the valley, and at this point Dinosaurian bones are met with for the first time in considerable numbers. The following section obtained here can be taken as fairly characteristic of the rocks of the Edmonton series, as exposed in the river banks as far south as the mouth of Rosebud Creek:—

Characteristic section.

	FEET.	INCHES.
Light-coloured boulder-clay including many Laurentian boulders and pebbles—at least	10	0
Whitish clayey sandstone	20	0
Grey carbonaceous shale	12	0
Coal (burnt out)	2	4
Whitish clayey sandstone	15	0
Coal (a brown lignite)	2	3

	FEET.	INCHES.
Light-grey sandy shale, with six-inch band of ironstone near the top	25	0
Yellow sandy shale	6	0
Shale mixed with *coal*	[illegible]	0
Grey readily weathering sandstone with irregular masses of ironstone and reptilian bones	60	0
Lighter grey sandstone	5	0
Sandstone and ironstone	1	0
Light-grey rather hard sandy shale with irregular bands of ironstone	25	0
Layer of nodules of flinty ironstone containing impressions of plants	0	6
Light sandy shale	10	0
Hard ferruginous sandstone containing obscure plant impressions	2	6
Light-grey sandy shale	6	0
Rather hard lamellar sandstone	1	0
Light-grey shaly sandstone containing, especially in the lower portion, more or less irregular bands of ironstone nodules	110	0
	315	7

For the whole of the distance to the mouth of Rosebud Creek—forty-eight miles—the valley is from three to five hundred feet deep, with sides of horizontal sandstones and clays, such as those described in the above section. Seams of coal appear, run along for a short distance, and then die out. Great numbers of Dinosaurian bones are scattered through the rocks underlying this part of the country. Dinosaurian bones.

At the mouth of Rosebud Creek, a low bank near the water's edge shows the following section:—

	FEET.	INCHES.
Coal	0	8
Reddish shale	5	0
Compact *coal*	6	10
Sandy shale with thin bands of sandstone	8	0
White clayey sandstone	1	0
Greyish sandy shale	7	0
Coal	1	3
Grey shale	to water's edge	

Mr. McConnell, who traversed the river from this point down to its mouth, in 1883, examined this seam, and refers it to the same horizon as the coal seam at Blackfoot Crossing, placing it at about one hundred and sixty feet above the Pierre.*

* Geol. Survey Report for 1882-84, p. 95 C.

An analysis of it was made by Mr. Hoffmann, with the following result:—

	Slow Coking	*Fast Coking.*
Hygroscopic water..................	13·08	13·08
Volatile combustible matter..........	31·49	34·50
Fixed carbon..........................	51·35	48·34
Ash	4·08	4·08
	100·00	100·00
Indicated power of fuel in calories....	—	5347

Tributaries of Red Deer River.

Fallen Timber Creek. In descending Red Deer River, the first affluent of any considerable size, is Kow-ich-ti-kow or Fallen Timber Creek, which rises on the eastern face of the Rocky Mountains, and reaches the eastern edge of the foot-hills at an elevation of 4,200 feet. A few rock exposures are to be seen on the stream, the first being in the north-east corner of township 30, range 6, west of the fifth principal meridian, where light grey sandstones and sandy shales of the Paskapoo subdivision of the Laramie, crop out, dipping N. 70° E. $< 10°$. Again at the northern bend of the creek there is an exposure of fifty feet of light-grey sandstones underlain by light-grey sandy shales. The lower part of the valley is open and swampy, but about a mile above the junction of the stream with the Red Deer, a low ridge runs out from the west, exposing thirty feet of rather hard, coarse, grey sandstone and sandy shale, dipping 3° to the north-west. Lying against this sandstone ridge and extending on both sides of it is a bed of quartzite pebbles, three feet thick. In one place it is seen lying directly on the sandstone. It continues north across the Red Deer to Bearberry Creek, and also from the western edge of the foot-hills to the ridge east of the mouth of Fallen Timber Creek, and then for several miles north along the Red Deer River, forming a plain covered on the north side of the Red Deer with excellent bunch-grass and on the south side with dwarf birch and willow. This evidently, has, in comparatively recent times been the site of a shallow lake or of a wide shallow expansion of the river, into which the quartzite pebbles derived from the mountains or perhaps more directly from the higher benches in the upper parts of the valley, were carried and deposited evenly over its bed, while the lighter sediments were carried still further down the stream.

Sandstone and sandy shales.

† Loc. cit., p. 15 M.

Passing over Bearberry Creek and several other small streams, we come to James River or the North Fork, which flows into the Red Deer from the west. It is the outlet of some small lakes in a gap in the outer range of the mountains, and after a course of about forty miles unites its waters with those of the Red Deer River. At the crossing of the old Blackfoot pack-trail to Rocky Mountain House, it is sixty feet wide and one foot deep, flowing over a bed of quartzite pebbles. The valley is fifty feet deep and from a quarter to half a mile wide, its bottom being a grassy sward underlain by two to three feet of rich alluvial soil resting on a bed of quartzite pebbles. Beyond this point the valley of James River has not yet been examined. Coal is reported to occur in large quantities further up the stream, but the exact position and extent of the deposit is as yet unknown, though in all probability it is within the disturbed foot-hill belt. **James River.** **Coal reported.**

North and north-east of James River, Raven River drains a considerable extent of swampy and wooded country, though only one of its branches, namely, that which is followed by the trail from Calgary to Rocky Mountain House, has as yet been examined. This stream rises in a marshy flat near the bend of Clearwater River, and flows south-east through a sloping, grassy or lightly-wooded valley, the sides of which rise in clay or gravel terraces to the hills behind. It is probable that the Clearwater at one time flowed to the south through this valley to join the Red Deer, but the gradual southern elevation of the country, assisted doubtless by a temporary blocking up of the old channel, diverted its waters to the north, causing them to carve out the narrow valley through which they flow to join those of the Saskatchewan. **Raven River.** **Old terraced valley.**

Little Red Deer River flows into the Red Deer fourteen miles below the mouth of Raven River. It rises in the eastern range of the Rocky Mountains and leaves the foot-hills in lat. 51° 30′, long. W. 114° 41′, at an elevation of 4,000 feet, cutting a narrow gorge through a sharp anticlinal of Laramie sandstones. Below this the valley is sloping, with a bottom underlain with quartzite gravel, and rises in two or three terraces to the level of the surrounding country. Very few rock exposures are to be seen, and those that appear through the sod are light-grey sandstones and sandy shales dipping north-easterly at a gradually decreasing angle. Following the river through the wide swampy valley to the point where it turns sharply to the east a little south of Hawk Hill, in lat. 51° 49′, an exposure occurs which shows about one hundred feet of horizontal, light-grey and yellowish, rather hard sandstone, interstratified with greyish-green sandy shales, and which represents an horizon high in the Paskapoo series. Six miles further down and a short distance below the mouth of Dog Pound Creek, true boulder-clay was seen for the first time in descending the river but **Little Red Deer River.**

5

Superficial deposits.

in less than a mile, all three divisions of the superficial deposits were met with, the following being the section exposed:

	FEET.
Light-coloured clay containing but few boulders	12
Dark-coloured boulder-clay	12
Quartzite pebble bed (to water's edge)	15

Pre-glacial valley.

As the banks both above and below this are composed of the sandstones and shales of the Laramie, the presence of the regular beds of boulder-clay would indicate the existence of a pre-glacial valley, which, however, was not filled up to the level of the surrounding country. Other exposures of boulder-clay are seen on the north side of the river; in one place thirty feet of light-coloured sandy boulder-clay, with numerous boulders of quartzite and sandstone, is exposed under eight feet of light-coloured, obscurely stratified sandy clay.

On the south side of the valley, as far down as the crossing of the Rocky Mountain House trail, light-grey and greenish sandy shale, intercalated with bands of ferruginous sandstone, crop out at intervals; and at the crossing of the trail, where the valley is seventy-five feet deep, these sandy shales are overlain by quartzite gravel in a matrix of sandy clay. Along the remaining part of the course of the Little Red Deer down to its mouth, a distance of fourteen miles, no rocks were seen, the bottom of the valley being flat and swampy while the sides rise gradually to the surrounding plain.

In some of the small valleys that are found on the northern side of the ridge separating the waters of the Bow from those of the Red Deer, and that are drained by streams flowing into Dog Pound Creek, some low exposures of horizontal sandstone occur, but in the valley of this stream between the mouth of Rock Creek and the Little Red Deer, no rock is seen in place, the only exposures met with being low cut-banks of stratified sand. West of the head of the Dog Pound, the country lying between the Bow and Ghost rivers and the Little Red Deer consists of a series of high ridges composed of sandstone more or less vertical, separated by swampy valleys, underlain, at least wherever the rocks were seen, by soft dark shales.

Medicine River.

A mile below the mouth of Little Red Deer River the Medicine River joins the Red Deer from the north. It rises on the face of a range of hills separating the drainage area of the latter river from that of the North Saskatchewan, and, after a course of sixty-five miles, empties into the Red Deer in a stream forty feet wide and two feet deep.

On the upper part of the main branch, the bottom of the river is a soft sand, and the banks for the most part are a light-yellow sandy clay holding some pebbles; this clay is, in places, of glacial origin, but

in most cases, especially close to the channel of the creek, it is derived from the degradation of boulder-clays and Laramie clays and sandstones. Near the trail-crossing of the west branch or Horse Pound Creek, under ten feet of fine yellowish sand there are thirty feet of light-grey thin-bedded sandstone and sandy shale, below which to the water's edge there are eight feet of light-grey compact sandstone. Further down along this branch, outcrops of similar sandstone and shales occur at intervals and at its mouth there is a low exposure of horizontal, soft, yellowish-grey, false-bedded sandstone, similar to that seen at the trail-crossing of Rosebud Creek, as well as in some high cliffs on the Saskatchewan thirty-five miles below the mouth of the Brazeau River. **Sandstone cliffs**

Below the Forks, the river flows in a wide, gently sloping valley, the bottom of which is covered with a moderately thick layer of a sandy superficial deposit.

On the east side of the valley of Medicine River, a high ridge separates it from the valleys of the Blind Man and Red Deer rivers. This ridge starts abruptly in township 41, range 3, in a rounded and partly-wooded hill, 450 feet high, and with an elevation of 3,500 feet above the sea, and runs S. 40°. E. till it gradually falls to the level of the surrounding country. It is cut through by several narrow transverse valleys which, though now dry, have all the appearance of having been the channels of ancient streams. Along the edge of this ridge, from bottom to top, horizontal bands of hard, grey, thin-bedded sandstone are seen projecting through the superficial covering of sandy clay, which is derived from the wearing away of the sandstones and, doubtless also, shales beneath. But, though there appears to be little or no true boulder-clay on the higher parts of the ridge, its surface up to its very summit, is scattered over with a large number of boulders, two-thirds of which are of gneiss, and, doubtless, derived from the east or north-east, presenting every appearance of having been dropped from ice which had stranded on this sandstone hill, then a shoal or bank in the glacial sea. **Laurentian boulders.**

The ridge to the west of Medicine River is one hundred and fifty feet higher than the one just mentioned, and on it, too, a great many Laurentian boulders are scattered, perhaps, up to its summit, though none were noticed till we had descended two hundred feet.

Thirty-five miles below the mouth of Medicine River, Blind Man or Paskapoo River flows into the Red Deer from the north-west. The eastern of its two main branches rises in a wide, sloping valley, with low, swampy bottom, while the western branch is fed by small streams that flow from the face of the ridge that forms the watershed between the Red Deer and North Saskatchewan rivers. The stream **Blind Man River.**

flows through its whole course of sixty-two miles over rocks of the Paskapoo or upper sub-division of the Laramie. On the west branch, a mile and a half above where the east branch joins it, the following section is seen :—

Paskapoo sandstones.

	Feet.	Inches.
Dark grey sandy clay containing a few small pebbles of quartzite with occasionally one of gneiss	6	0
Coarse yellow sandstone running into a yellow ferruginous sandy shale	8	0
Olive-green clayey shale	6	0
Impure lignite	0	5
Similar olive shale	2	0
Greenish-yellow, rather hard, much-fractured sandstone containing nodules of hard, fine-grained, compact sandstone	5	0
Bluish-grey fine clay-shale	2	0
Alternating bands of bluish and greenish clay-shale and soft sandstone with occasionally rounded nodules of hard sandstone	30	0
	59	5

A mile and a half further up-stream, the seam of lignite is again exposed, underlain by eight feet of greenish and grey clay shale. From this exposure down the stream to the crossing of the Rocky Mountain House trail, a distance of twenty-seven miles, very few rock exposures are met with, and what are seen consist of such light-grey sandstones and sandy shales as are common throughout the formation. At the crossing, the following section may be seen :—

	Feet.
Rather hard, compact, light yellowish-grey sandstone	6
Grey, thin-bedded, rather hard sandstone	6
Light-bluish sandy shale, including large irregular limestone concretions	15

Limestone concretions with fossils.

In these limestone concretions, are numerous and often well-preserved specimens of the following species of fossils :—

Sphærium formosum ?, var., *Physa Copei*, *Hydrobia*, sp., *Campeloma producta*, *Viviparus Leai*, *Valvata filosa*, *Valvata bicincta*, tooth of shark like *Oxyrhina*.

From the Rocky Mountain House trail to the mouth of the river, a distance of sixteen miles, coarse-grained sandstone, interstratified with sandy shale, crops out at intervals. Three quarters of a mile up-stream from the Red Deer, a six-inch seam of coal crops out forty feet above the bed of the stream, underlain by a thin bed of marly sand, in which the following species of fossils were collected :—

Fossils.

Limnæa tenuicostata, *Physa Copei*, *Acroloxus radiatulus*, *Valvata filosa*, *Valvata bicincta*, and fragments of *Hydrobia* and *Sphærium*.

The mouth of this river is approximately a hundred feet higher than the outcrop of the twelve-feet coal seam on the Red Deer River twenty miles further down the stream, and as the rocks in this distance have a light dip westward of five to ten feet to the mile, the maximum height of the bottom of the rocks here exposed may be taken as three hundred feet above the coal seam, which is at the top of the Edmonton series.

Western Drainage Area of the Red Deer River.

In descending Rosebud Creek the first rock exposures met with are on a small creek running in from the south, half way between the Morley and Calgary trails. They consist of rather hard, coarse-grained, yellowish-grey sandstone, standing out from the grassy hill-sides, and weathering into curiously pillared shapes. They are thick-bedded, and horizontal, but exhibit false bedding dipping at every conceivable angle. Two miles and a-half further down the valley, other exposures were seen, shewing light-grey sandy shale and sandstone with some included limestone nodules containing *Viviparus Leai.* At the crossing of the Calgary-Edmonton trail, coarse-grained, soft, yellowish and whitish sandstones crop out in the side of the valley, and close to the edge of the creek, under about two feet of thin-bedded sandstone, a thin seam of powdery lignite can be detected, underlain by a soft yellow sandstone with nodular clay concretions. On the Calgary-Edmonton trail southward as far as the Sharp Hills, thick-bedded, rather hard, light-grey sandstone is seen to crop out in the valleys of small creeks, and in the Sharp Hills, coarse, light-coloured, thin-bedded sandstones are seen projecting through the soil. The hills are strewn with numerous boulders, mostly quartzitic, but a few are gneissoid. On the Rosebud, for two miles below the trail-crossing, false-bedded, pillared sandstones, similar to those already described, are seen in small exposures, though the banks are mostly grassy; and again six miles further down, under a bed of laminated sandstone, there is an outcrop of thirty feet of light-grey clay-shale, here and there stained with iron, and four miles lower, false-bedded sandstone re-appears similar to that seen near the Calgary-Edmonton trail.

Rosebud Creek.

Sharp Hills.

Pillared sandstones.

In the flat through which the river runs for several miles after it bends to the east, low banks of white sandy clay skirt the stream, and where the valley again contracts to its usual width, eighty feet of white stratified clay with some thin bands of sand and a few included pebbles of quartzite and gneiss, appear on the north side of the valley. Half a mile below this, some fragments of sandstone were found in the bed of the creek, containing beautifully preserved specimens

of *Thaumastus limnæiformis* with fragments of *Ostrea*, *Viviparus trachæiformis ?* and carbonized fragments of fossil wood. The sides of the valley, for the next eighteen miles, are composed of clay and are sometimes abruptly scarped close to the bends of the stream. The following may be taken as typical sections: In a bank forty feet high, the upper fifteen feet are composed of white laminated clay, without pebbles, running down into a soft shaly clay underlain by sandy clay containing pebbles of quartzite and rounded fragments of coal; and again in a bank eighty feet high :—

Sands and clays

	FEET.
White laminated clay	15
Thick-bedded compact clay	12
Sandy clay with boulders	15
Stratified sand, the grains being somewhat rounded	38
	80

A short distance below the mouth of Service Berry Creek of the Dominion Lands map of 1884, the underlying rocks re-appear, the following section being exposed :—

	FEET.	INCHES.
White laminated clay, at the top	..	..
Sandy conglomerate or boulder-clay	20	0
Irregular seam of *coal*	0	1
Whitish sandy conglomerate or boulder-clay, the pebbles being few and small	4	0
Rather hard clayey sandstone	8	0
	32	1

Edmonton series.

This latter bed is the first outcrop seen in descending this stream belonging to the Edmonton or coal-bearing subdivision of the Laramie, the rocks met with above it belonging all to the Paskapoo or upper subdivision.

Half a mile further east, at the mouth of a small creek which flows in from the south, under the laminated clay, is a bed of clay including boulders, and under it a reddish sandstone passing downwards into a sandy clay which contains ironstone nodules and fragments of reticulate leaves, among which *Trapa borealis* was recognizable. A mile further down the stream, the following section was observed :—

	FEET.	INCHES.
Laminated clay, at the top	..	..
Clayey sandstone	20	0
Coal	1	6
Clayey sandstone, with a layer of septarian ironstone nodules	30	0

Steep naked banks.

From this point to the mouth of the creek, the valley gradually increases in depth, the sides become more naked and abrupt and steep bare conical hills or "buttes" of the banded clay and sandstone often stand in the middle of the narrow gorge, having been detached from the face of the high bank by the action of atmospheric agencies, assisted to some extent by the rapid stream below. A number of excellent sections of the rocks of the Edmonton series are here to be seen, consisting, for the most part, of light-grey or whitish argillaceous sandstone, rather coarse-grained, and lying in thick compact beds. These are interstratified with thick beds of light-grey sandy shale, and occasionally with thin seams of coal or of carbonaceous shale. The greatest thickness observed in any of these coal seams was two feet, and even that varied in a short distance. Beds of impalpable clay were also observed, very similar to that collected by Dr. Selwyn at Edmonton, in 1873, and determined by Dr. Harrington as a hydrated silicate of alumina.* The beds have a light westerly dip of about twenty-five feet to the mile, which will give a total thickness of about 750 feet for the rocks exposed along the creek in the lower fifteen miles of its course. The following section, which was seen five miles above its mouth, may be taken as typical:—

Typical section.

	FEET.	INCHES.
Clayey sandstone and clay-shale	70	0
Carbonaceous shale	0	6
Light-grey clayey sandstone and clay-shale	8	0
Layer of hard sandstone ... 6 inches to	2	0
Clay shale with ironstone	4	0
Coaly shale	1	0
Light-grey clay-shale	1	3
Coaly shale	1	4
C ayey sandstone and clay-shale	15	0
Coal	1	2
Clayey sandstone and clay-shale	46	0
Coal	0	6
Clayey sandstone and clay-shale	20	0
Coal, moderately compact	2	0
Clayey sandstone and clay-shale with ironstone	13	0
Impure *coal*	1	3
Clayey sandstone and clay-shale with ironstone	14	0
Carbonaceous shale	0	4
Coal	1	10
Clay-shale	9	0
	212	2

* Geol. Survey Report for 1873-74. p. 38.

Knee Hills Creek.

On Knee Hills Creek twenty mile due east of the bridge across Rosebud Creek, and at an elevation of 2850 feet, hard grey, in places brownish-weathering, sandstones crop out along the sides of the grassy bank of the valley, and a short distance to the south, in the valley of a small stream flowing in from the west, twenty feet of rather soft, light-grey coarse-grained sandstone, shaly in places, overlain by six feet of light-grey clay containing a few pebbles mostly of quartzite, but some few of gneiss, are exposed. The grey and brownish sandstones crop out in the valley at irregular intervals for thirteen miles, where the following section is seen:—

	FEET.
Brownish thin-bedded sandstone........................	10
Somewhat soft grey sandstone with large rounded masses of coarse-grained ferruginous sandstone...............	8
Olive sandy shale	10

Four miles further down the creek, the following section is seen:—

	FEET.
Rather hard, brown, false-bedded sandstone.............	12
Olive sandy shale....................................	40
Hard ferruginous sandstone..........................	6
Grey and olive sandy shale and sandstone	25
Beds concealed	25
Dark friable clay-shale, at water's edge..................	..
	108

Below this, for two miles, the sides of the valley are sloping and grassy, being no doubt composed of the last mentioned shale, till grey sandy clays again crop out. At a short distance further down the stream a seam of coal is seen at the water's edge, and a mile and a quarter below the following section is exposed:—

	FEET.	INCHES.
Whitish clayey sandstone.......................	30	0
Clay-shale................	1	6
Coal (compact)................................	4	0
Carboniferous shale mixed with lignite...........	0	10
Rather hard clayey sandstone turning into clay-shale at the top..............................	25	0

The above mentioned whitish sandstone is the first of that nature seen in descending the stream. It is at the top of the Edmonton subdivision of the Laramie adopted in this report, and doubtless occupies the same position as the "light-coloured argillaceous sands" recorded by Mr. McConnell as occurring near the top of the

Wintering Hills,* and underlying sixty feet of dark, plastic clays, these latter being doubtless represented by the dark clay-shale found occurring at the water's edge in the section on Knee Hills Creek. The coal mentioned in the last section occurs in a compact seam, breaking off into rectangular masses of considerable size. It has been examined by Mr. Hoffmann, the chemist of the Survey, who reports that "it is a lignite of superior quality; becomes somewhat fissured by exposure to the air, but might be kept for a short time in a sound condition if protected from the weather; when freshly mined is, in all probability, a firm fuel, and would bear transport to moderate distances. A proximate analysis of a sample collected from this seam gave— Coal.

Hygroscopic water	9·86
Volatile, combustible matter	34·89
Fixed carbon	46·57
Ash	8·68
	100·00

Apart from the structure being somewhat more coarsely lamellar, it is not very dissimilar to specimens 6 and 7 of Report for 1884, pp. 15 and 16 M." On descending the valley, the coal seam is seen to rise at the rate of about twenty-five feet to the mile. Mr. McConnell states that a thin seam of lignite is met with in the Wintering Hills in connection with the "light-coloured argillaceous sands" above mentioned, and in all probability it is the continuation of the same seam. The extension northward of this seam will be considered more fully on a succeeding page of this report. Down the stream, exposures become more numerous as the valley becomes deeper and more precipitous, the banks being composed of grey and whitish soft clayey sandstone and grey sandy shale, with bands and nodules of ironstone. In some of these nodules, which were found in a bed of soft sandstone Fossils. outcropping about eight miles above the mouth of the creek, well-preserved specimens of *Unio Danæ* and *Panopæa simulatrix,* and, a short distance further down, a long bone from one of the extremities of a Dinosaur was found imbedded in a large block of ferruginous sandstone. Similar shales and sandstones continue to form the banks of the valley to its junction with that of the Red Deer. Several thin seams of coal run for short distances as black horizontal bands between the thick beds of white clay and sandstone, giving, with the reddish ferruginous bands of somewhat similar thickness, an exceedingly variegated and often picturesque appearance to these bare

*Geol. Survey Report for 1884. p. 93.

rocky hill sides—an appearance which induced Dr. Hector, in 1859, to apply the name "Banded Clays" to this portion of the Laramie. Two miles above the mouth of the creek, where the Blackfoot pack-trail crosses the valley, similar rocks are exposed, and in a bed of the whitish sandstones the head of a large carnivorous Dinosaur was found, which is stated by Prof. Cope to be the largest Dinosaur yet found in the Laramie, and to be allied to his Cretaceous species, *Lælaps incrassatus.*

Dinosaurian remains.

The ridge which rises between Knee Hills and Rosebud creeks is deeply cut by numerous coulées, which lead down into the valleys of either stream, and show in many places excellent sections of the Edmonton series, though, in a few places, the bottom beds of the next succeeding subdivision are also slightly exposed. A number of the coulées which run northwards have water in them at almost all seasons of the year; a few clumps of poplar grow along their sides, and they would afford abundant shelter for large herds of cattle, both from the direct rays of the sun in summer and from the storms of winter, while there would always be a plentiful supply of nutritious grass on the surrounding plateau.

Three Hills Creek.

In the upper portion of Three Hills Creek, where it runs in the bottom of a wide grassy valley, no exposures of the underlying rock were met with, the banks being composed of stratified sand and gravel. In the Knee Hills, however, which rise to the west of the creek, croppings of hard grey sandstones, belonging to the Paskapoo subdivision of the Laramie, are seen. Directly east of the southern end of these hills at an elevation of 2,600 feet, grey and olive sandy shales and hard, coarse-grained grey brownish-weathering sandstone crop out close to the creek. Five miles further down, forty feet of similar shales and sandstones occur under thirty feet of sandy, stratified, boulder-clay, overlain by eight feet of stratified yellowish clay. In the sandstone are bands of somewhat bituminous, sandy shale, containing numerous fragments of fossils, among which may be mentioned the tooth of a Dinosaur, *Sphærium*, *Valvata*, *Unio*, *Goniobasis ?*, opercula of *Viviparus*, and carbonised stems of plants, and in some blocks of sandstone at the bottom of the bank, *Campeloma producta* and *Thaumastus limnæiformis.* The latter of these species has not been found actually in place within the limits of this map, but in the summer of 1885, it was found on the banks of the River opposite the mouth of Fish Creek, associated with *C. producta*, *Viviparus Leai*, and fragments of a *Unio.*

Paskapoo series

Edmonton series.

Four miles above the mouth of Devil's Pine Creek, whitish clayey sandstones begin to appear in the sides of the valley, overlain by a bed of dark clay shale. Under a thickness of twenty-five feet of the sandstone, a seam of compact coal two feet two inches thick is exposed,

forming the continuation of the four-feet seam on Knee Hill Creek, though the beds here seem to have a slightly higher westerly dip than at the last named place. The white clayey sandstone and sandy shale form the sides of the valley to its mouth, and the following section which is shown at the Forks of Devil's Pine and Three Hills creeks, will be typical for the whole distance.

	FEET.	INCHES.
Rather hard, light-brown sandstone, at the top....	..	..
Light-grey and whitish sandstone and sandy shale, with some ironstone....	100	0
Coal	0	8
Similar sandstone and shale, with ironstone nodules and ferruginous sandstone in which was found *Corbicula occidentalis* and *Panopæa curta*....	100	0
Coaly shale....	1	6
Coal	1	0
Carbonaceous shale....	..	..
	203	2

Fragments of Dinosaurian bones and some plant remains, among which were fruits of a species of *Carpolithes* were found at the bottom of the bank.

Devil's Pine Creek, where it flows from Devil's Pine Lake, runs over a gravel bed, in a valley with sloping grassy sides. Where next met with, fourteen miles further down, it runs on a muddy bottom in a wide, sloping valley, and the stream was followed for four miles before any croppings of the underlying rocks were seen. The exposure consisted of— Devil's Pine Creek.

	FEET.	INCHES.
Light coloured boulder-clay, at the top....	..	..
Coal....	1	6
Light-coloured clay-shale....	10	0
Coal....	0	3
Light-coloured clay-shale, at the bottom....	..	..

For the next fourteen miles the sides of the valley are composed of superficial sands and clays underlain by the yellowish stratified clay and the dark-coloured columnar boulder-clay. Six and a-half miles above the mouth of the creek, the following section is exposed:--

	FEET.
Dark, superficial sandy clay .... } Light-yellowish stratified clay .... }	15
Hard dark-coloured columnar boulder-clay....	35
Grey sandy clay-shale and light-grey sandstone....	30
	80

Coal seam.

Half a mile further down the creek, a seam of coal is seen at the water's edge, overlain by ten feet of white clayey sandstone, and dipping slightly towards the west; and a short distance further east, the same seam is fully exposed above the water, showing a thickness of four feet six inches, underlain by eight feet of dark sandy shale, and overlain evenly for a considerable distance by the columnar boulder-clay. Specimens from this seam have been examined by Mr. Hoffmann, who describes it as a lignite of good quality, very similar to that cropping out on Knee Hills Creek, and described on p. 73 E of this report. From this point down, the sides of the valley are composed of the white clays, shales and sandstones of the Edmonton subdivision of the Laramie.

Surcee Butte.

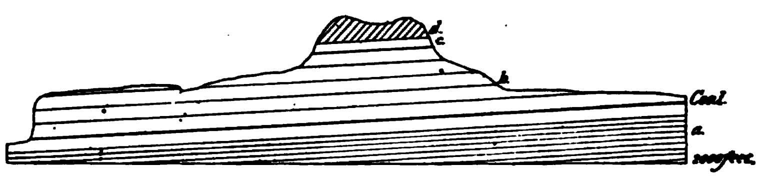
Surcee Butte, which lies five miles north of the mouth of this creek, is a rounded eminence rising about 300 feet above the level of the surrounding plain. Its sides are sloping and grassy, except towards the north where close to the summit there is an exposure of forty feet of light-grey clay-shale and light-yellowish clayey sandstone, including about the middle a band of dark shale with some hard sandstone containing impressions of ferns and exogens.

North of the headwaters of the streams just described, as well as around Quill Lake, the country is very rolling, with occasional wide flat stretches, no rock exposures being seen.

Hand Hills.

Hand Hills.

These hills form a high table land, rising 1,000 feet above the general level of the surrounding prairie, and 1,350 feet above the level of Red Deer River to the south-west.



a Pierre Shales. SECTION OF THE HAND HILL. *c Paskapoo series.*
b Edmonton Series. *d Miocene.*

They are called by the Crees, Michichi Ispatinan or Hand Hills, on account of their resemblance to the outstretched fingers of the hand, the top of the table land not being flat, but composed of five ridges

which radiate from a centre lying to the south-east. To the north-west, west, and southwest, they rise abruptly from the sloping plain in bold escarpments five hundred feet high, but to the east they slope gradually, interrupted here and there by rolling hills, to the valley of Bull Pound Creek, where they end in a steep, though grassy slope, extending down to the wide plain through which this creek winds. This latter slope is, however, cut by numerous coulées, along the sides of which excellent exposures of the white banded clays and sandstones of the Edmonton series may be seen.

On the western face of the Hills the following may be taken as a generalised section of the rocks exposed:— **Section on western face.**

	FEET.	INCHES.
Loose quartzite pebbles imbedded in a sandy calcareous matrix	15	0
Quartzite pebbles cemented into a hard conglomerate by calcareous cement	2	0
Loose mass of pebbles, sand and marl	10	0
Light-grey and yellowish, stratified, argillaceous marls, with some intercalated beds of fine-grained brown sands. In the upper beds some thin layers of limestone occur, which show on broken surfaces dendritic markings of oxide of manganese	270	0
Light-brown, false-bedded sandstones	100	0
Grey clay-shale	30	0
Lignite	3	6
Plastic clay	2	0
Lignite	4	6
Grey clay-shale and white clayey sandstone for several hundred feet	..	..
	437	0

In the lowest beds of this section, we have the typical rocks of the Edmonton subdivision of the Laramie. If we assume for these a south-westerly dip of fifteen feet to the mile, which is about what is indicated by a line drawn from the top of the whitish clay shale and sandstone in these hills to the corresponding beds in the Wintering Hills, we have here a thickness of seven hundred feet shown for this subdivision. Overlying this lower subdivision of the Laramie, a hundred feet of brownish sandstone of the Paskapoo subdivision crop out along the face of the escarpment, the rest of the upper portion of this series having there been eroded away. Lying immediately on the top of these brownish and lamellar sandstones, stratified argillaceous marls and sands extend upwards for two hundred and seventy feet, the beds being as far as can be seen, perfectly horizontal. This total thickness is not exposed in any one continuous section, the best **Edmonton series.** **Paskapoo series** **Miocene beds.**

exposures of the upper beds occurring in the highest of the western escarpments, where they are seen to run up into the overlying conglomerates. The lower beds, and the contact with the underlying sandstone, are visible only in some coulées on the south-west side of the hills leading down into Shell Creek. On some of the highest points of the hills, a bed of twenty-seven feet of quartzite gravel overlies the stratified marls, the matrix being a mixture of sand and lime, sometimes loose and sometimes cementing the mass into an exceedingly hard conglomerate. These conglomerates, with the underlying marls and sands, are so similar to the Miocene beds of the Cypress Hills, that I have very little hesitation, even in the absence of fossil remains, in classing them in that formation, although, as their material was doubtless brought down from the mountains to the west by a different streams, the deposition of the two may not have been exactly contemporaneous. The conglomerates in the upper part of this series being very much harder than the underlying sandstones and shales of the Laramie, offered a much greater resistance to the denuding agencies which wore down the surface of the surrounding country, thus preserving these hills as an elevated plateau rising 1,000 feet above the level of the adjoining prairie. They have, however, been themselves largely denuded, and the quartzite pebbles of the upper beds have been re-distributed over the greater portion of the hills lying on the eroded surface of the underlying marls, which in one place were observed to have a thickness of not more than ten feet above the Laramie sandstone, the re-distributed gravels having a thickness of fourteen feet. Mr. McConnell found similar gravels along the south Saskatchewan, and around the base of the Cypress Hill, and as they underlie and are evidently older than the boulder-clay, he has classed them as Pliocene under the name South Saskatchewan group.* As this is a similar re-distribution of Miocene gravels, it seems probable that they are of the same age.

Quartzite conglomerate.

Re-distributed gravels.

Bull Pound Creek.

Immediately east of the Hand Hills, Bull Pound Creek runs southward into the Red Deer River. Forty miles above its mouth, the light-grey and whitish sandstones of the Edmonton series crop out on the sides of lateral valleys running in from the higher ground to the east. Lower down the wide, flat valley in which this small stream winds, exposures of similar whitish sandstone and sandy shale, with, in many places, numerous ironstone nodules and thin beds of lignite, occur on either side, having often a local dip of several degrees. In the most southerly of these exposures on the east side of the creek, a seam of lignite outcrops, four feet six inches of which were seen, but both the bottom and the top were covered by land-slides. Though the

* Geol. Survey Report for 1885, pp. 59, 70 c.

lignite was moderately compact, as far as seen, it was of poor quality and would be of little use as fuel, except for local supply. South of this point, the land gradually lowers for about three miles till it reaches the level of the plain to the south-east. On the west side of the creek, the country is roughly undulating and hummocky for twelve miles further south, forming a wide base round the foot of the Hand Hills in that direction. A mile below the crossing of the Lord Lorne trail, the creek enters a narrow valley, the sides being at first composed of sand and clay, but two miles and a-half further down, horizontal light-brown sandstones begin to appear, and shortly afterwards become interstratified with slate-coloured and light-brown sandy shale. Seven miles below the crossing of the Lorne trail, a small *Baculites*, together with fragments of *Lunatia concinna*, was found in the brown sandstone, showing that we had reached the marine shales and sandstones of the Fox Hill and Pierre group. Below this the valley becomes deeper and the sandstone gradually gives place to a dark clay shale, containing numerous crystals of selenite and ironstone nodules; eight miles above the mouth, where the banks are seventy-five feet high, *Lucina occidentalis* and *Baculites compressus* were collected in this dark clay shale.

Fox Hill and Pierre group.

Berry Creek is very similar in character to Bull Pound Creek, except that in its lower portion, it runs in a wide, open, grassy valley. Near the mouth of Dead Fish Creek, which is, however, eleven miles below the southern limit of the accompanying map, there is a low exposure of dark clay-shale with ironstone nodules. Fourteen miles further up-stream, at the crossing of an old trail, forty feet of light-coloured sandstone interbedded with dark-grey shale, including beds and nodules of ironstone, were seen. In these sandstones and shales were found *Gervillia recta*, var. *borealis*, *Tancredia Americana* and *Placenticeras placenta*, var. *intercalare*, along with a fossil plant, described by Sir J. W. Dawson as *Abietites Tyrrellii*. North of this point, the creek, for sixteen miles, runs in a moderately straight valley, the sides of which, averaging about fifty feet in height, are composed mostly of the dark-coloured boulder-clay. For the next ten miles, the valley is crooked and sometimes ill-defined, a few exposures of boulder-clay and stratified sand containing boulders, occurring at the bends of the stream. At the junction of a small stream from the west, sixty feet of dark-coloured sandy shale containing crystals of selenite and spherical hollow nodules of ironstone, are exposed below the boulder-clay, and for six miles up this western branch, similar shales occasionally crop out. At this point, the dark shales are seen to be overlain by light-grey and yellowish sandy shales, which, a little further up, form low bad-land banks close to the creek, where a seam of lignite crops out two feet six

Berry Creek.

Fossils.

inches in thickness. For the rest of the course of this western branch, white sandstones are occasionally seen along its banks. On the main creek itself, four miles above the mouth of the last mentioned branch, are exposures of dark-grey iron-stained clay-shale containing crystals of selenite and spherical nodules of ironstone, on the top of which rests a layer of hard brown sandstone, and half a mile further up, under the dark boulder-clay, light-brown sandstone and grey clay-shale are seen in a low escarpment. Above this, the valley rapidly loses its definite character, and spreads out into a wide clay flat very similar to that on the Bull Pound east of the Hand Hills. Fourteen miles further north, the valley again contracts but becomes much more irregular, and eventually widens out again into the broad flats east of Sullivan Lake. A few exposures of light-grey clay-shale occur on these upper portions; and on the ridge to the west, in coulées and small areas of bad lands, the whitish clayey sandstones and sandy shale of the Laramie with numerous nodules of flinty ironstone, outcrop in sections, in some places, fifty feet high. Near the creek, numerous Laurentian erratics are scattered over the sloping sides of the valley.

Wide clay-flat.

Sullivan Lake. Sullivan Lake, the water of which is white from suspended clayey matter, has probably at one time been connected with the upper end of this creek, but is now quite cut off from it and without outlet. Around the southern main portion of the lake, the land is low, but it rises on the western and southern sides into rolling hills at a short distance from the shore. On both sides of the north-western arm, bad-land banks are seen at a distance of about half a mile back from the lake, a white mud flat stretching from their base to the water's edge. On the western side, where the rocks were more particularly examined, the scarped hill-sides showed the usual section of the lower part of the Laramie, white and grey clayey sandstones and sandy shales interstratified with beds of ironstone and lignite; one of these latter is four feet in thickness, but very shaly and of poor quality. In some places it has been extensively burnt and the red and yellow cinders have fallen down and covered the banks.

Blood Indian Creek. Passing over the east branch of Berry Creek, Blood Indian Creek is the next stream flowing south into the Red Deer. Its banks, where we crossed it, were low and sloping, but in one place eight feet of typical dark grey Pierre shales, holding crystals of selenite, cropped out from under the overlying boulder-clay.

Sounding Creek. North of Blood Indian Creek, Sounding Creek flows eastward and then northward into Battle River. At the crossing of the Lord Lorne trail, its banks are ten feet high and are composed of boulder-clay overlying soft white sandstone, and four miles down the creek

under a layer of loose sand, ten feet of dark-grey Pierre shale is exposed. A mile and a half further down, there is a considerable local disturbance of the strata, two outcrops half a mile apart, showing soft yellow sandstone and dark clay shales dipping at angles of 70° and 50° respectively, though these are doubtless small local folds which do not bring up any considerable thickness of the underlying rocks. Three quarters of a mile below the last mentioned exposure, similarly disturbed, soft light-grey sandstones were met with, including bands of yellow nodular ironstone in which were found *Gervillia recta*, var. *borealis*, *Lunatia concinna* and a species of *Anchura*, and a mile and a half further east, about the centre of Range 8, there is a thirty-feet exposure of horizontal light-grey sandy shale filled with crystals of selenite and including a band of rounded nodules of ironstone. In and associated with these nodules a number of fossils were found, which, like those just mentioned, are characteristic of the Pierre, viz:—*Baculites grandis*, *Placenticeras placenta*, *Hydatina parvula* n. sp., *Linearia formosa*, *Pteria linguiformis*, *Protocardia subquadrata*, *Palæastacus ornatus*, n. sp., and a fin, centrum and spine of a fish.

Disturbed strata.

Fossils.

Dark clay-shales begin to appear below these sandy beds, a little further down the stream, and for twenty miles, low exposures of these shales are all that is seen of the underlying rocks. Near the western limit of range 5, however, the valley becomes narrow, with bad-land sides a hundred and twenty feet high, showing the following section:

	FEET.
Covered	20
Grey sandy shale with bands of nodular yellow ironstone.	20
Fine grey clay	10
Slate-grey clay-shale	50
Covered	20
	120

These beds are practically horizontal and are exposed almost continuously for about five miles, where the valley again becomes wide and sloping. The face of the bare white bank is in many places scattered over with numerous crystals of selenite, and one third of a mile below the above section, in a band of yellow ironstone, twenty-five feet from the bottom of the bank, fragments of *Placenticeras placenta* and a species of *Ostrea* were collected.

At its northern bend, the valley is very wide, with an extended intervale of adhesive impervious clay, and it is not till four miles north of the bend, that low exposures of grey clay shale again appear and extend for seven miles along the sides of the valley. The shales

here as before, contain numbers of crystals of selenite and are mixed with beds of clayey sandstone. For the next twenty-three miles, the valley is very wide, the creek expanding in one place into shallow "alkaline" lakes. Five miles to the east of these lakes, in township 33, range 4, a ridge rises by a gentle slope from the west, while on the eastern side it is washed out into two deep amphitheatre-like hollows. The sides of these hollows are about one hundred and forty feet high, and are composed of light-grey clayey sandstone and clay-shale with bands of light brown lignite, and, especially towards the bottom, bands of almost black nodular ironstone, while the shales in places contain a few crystals of selenite. These rocks lie on an anticlinal striking N. 85° E., evidently a local crumpling, which brings up the white beds of the Belly River series from beneath the shales of the Pierre. It was impossible to determine exactly the thickness of the beds here brought to the surface, but in one place, for a length of twelve hundred feet, they were found to dip N. 5° W. at an angle of 30°, which implies a thickness for the beds here exposed of six hundred feet, and neither the top nor bottom of the formation was seen in this section. This heavy dip of the strata in the centre of the surrounding flat-lying beds of the plains is very remarkable; a similar phenomenon was noticed by Dr. G. M. Dawson, on the Milk River, close to the international boundary, where beds of this Belly River series of the same age as those here seen are brought to the surface over a small area.*

Anticlinal fold.

Belly River series.

The next exposure seen while following the creek northward was on the east side of the valley in township 35, five miles above Sounding Lake, where ash-grey clay and clayey sandstone crop out in a number of small exposures extending for fifty feet up the side of the hill, representing some of the higher beds of the Belly River series. For the rest of the distance to Sounding Lake, the banks, though high, are grass-covered and rarely show any signs of the underlying rocks.

Neutral Hills.

The Neutral Hills are an irregular plateau rising gradually from the plains to the south to a height of five hundred and thirty-five feet above the surrounding country, and, especially in their north-western part, are cut through, by several deep depressions. The rolling, partly wooded hills to the north are composed of a pure or clayey sand washed down from the face of the higher plateau to the south, while the main ridge to the south is largely composed of the shales and sandstones of the Pierre, the sandstones being the most conspicuous, projecting as ledges from the sides of the hills. The best section is seen at the "Nose," where soft, brownish and light-grey clay-shales are exposed, containing nodules of ironstone, and having a vertical thick-

* See Geology and Resources of the 49th Parallel, p. 114.

ness of six hundred feet. In the upper part of this section, the shales contain large numbers of crystals of selenite, along with specimens of *Protocardia borealis* and *Baculites compressus*. At the bottom of the section, which is seen on Ribstone Creek, a small stream flowing northward immediately west of the "Nose," the rocks consist of dark-grey clay-shale associated with beds of brownish-yellow, friable sandstone, in which were found *Placenticeras placenta*, *Baculites compressus* and *Liopistha undata*. In the more easterly parts of the hills, the lowest beds are composed of the whitish sandy clays of the Belly River series.

These hills lie on the western side of the low anticlinal which stretches northward from the South Saskatchewan River, bringing to the surface the sandstones of the Belly River series, which has been preserved as hills by their capping of Pierre shales; which, though soft, offer more resistance to the denuding agencies than the sandstones above and below them. The tops and sides of the hills are scattered over with pebbles of chert and boulders of gneiss and limestone, often in great numbers.

Battle River and its Tributaries.

On or just west of the 114th meridian, a stream flows from Pigeon Lake and one from Battle Lake, which, after courses of eleven miles each, join to form Battle River. **Battle River.**

Pigeon Lake, the largest and most northerly of the two lakes, is eleven miles long and four to five miles wide. It is surrounded, except on the south-east side, by thickly wooded hills which rise from one to three hundred feet above the water. The sides and summits of these hills are strewn with gneissoid boulders, which also cover the shore of the lake, though at low water in some places a sandy beach stretches for a few yards between the edge of the water and the boulders. **Pigeon Lake.**

Battle Lake is much smaller, being only four and a-half miles long and half a mile wide, though it is reported to be very deep. It simply occupies the bottom of the old valley down which Battle River flows eastward; towards the west the bottom of this valley is occupied by an impassable morass. The south shore is four hundred feet high, and thickly wooded, while to the north the country is much lower and more open. At the west end of the lake there is a hill three hundred and ten feet high, the sides of which are scarped in numerous places, showing the following section which is very typical of the Paskapoo series:— **Battle Lake.**

Paskapoo beds.

	FEET.
Covered, the outer soil being sandy	70
Olive sandy shale containing towards the top concretionary nodules of grey limestone	30
Covered	50
Bands of rather hard yellow sandstone cropping out through the sod	30
Light-grey shaly sandstone	15
Light-yellowish or greenish-grey, rather soft, thick-bedded sandstone, false-bedded in places, weathering with rounded face, and towards the bottom mixed with some bands of sandy shale	60
Covered	40
Light-grey, lamellar, rather fine-grained sandstone	5
Covered	10
	310

Between Battle Lake and the mouth of Pigeon Creek, the bottom of the valley is very swampy, and small springs flow out of the bank, which is composed of the grey sandstone and shale of the Paskapoo subdivision of the Laramie.

Between the mouth of Pigeon Creek and that of Wolf Creek, the valley is open, with sloping sides, which but rarely show any indications of the character of the underlying rocks, but, where there are exposures, they are seen to be horizontal sandstones and shales of the Paskapoo series, similar to those occurring both higher up and lower down-stream.

Wolf Creek.

Wolf Creek is a small stream flowing in from the south, fifteen feet wide and a foot deep, with (except near its mouth) low grassy banks, showing nothing of particular geological interest. From the mouth of Wolf Creek to the "Leavings," the banks of the Battle River are low and overhung with willows, being composed of alluvial sand and clay. A mile below the "Leavings," on the Edmonton Trail, a bed of quartzite gravel, two feet thick, similar to that seen on the Red Deer near the mouth of the Blind Man, crops out on the north bank, a little above the water. Three miles further east, low banks of dark-coloured boulder clay are seen, overlain by twenty feet of stratified sand, in which false-bedding is excellently shown. The southern shore of Battle River Lake was not examined, but in crossing it and skirting for a short distance along its north-east side, no rock was seen in place, though its margin was found to be composed of a great number of gneissoid boulders, and on the west side, where the land is low and marshy, lumps of coal of considerable size are reported to have been picked up. North of Battle River Lake no exposures are met with till the river turns to the east, low escarpments of both the lower and the

Battle River Lake.

upper boulder-clay occur then at intervals along both sides of the stream. At the bend to the north, the banks become much higher, but for several miles are still composed of boulder-clay, underlain by a bed of quartzite pebbles. Six miles north of the last mentioned bend, the underlying Laramie rocks are seen for the first time as sandstones and olive sandy shales of the Paskapoo series, rising eight feet above the level of the water, which is here at an elevation of 2,450 feet. For the next three miles grey sandstone and sandy shale form the lower part of the bank, while the upper part is composed of the pebble bed overlain by light-coloured stratified boulder-clay. In one place, the bank shows thirty feet of sandstone and sandy shale, with a seam of coal five inches thick towards the top. In a depression in the upper bed of sandstone, probably the section of an ancient channel of a small stream, there are collected a great many large boulders, most of which are of quartzite; but some few are of gneiss, with numerous pebbles of ironstone. This pocket, along with the surrounding sandstones, is evenly overlain by a bed twelve feet thick of quartzite pebbles. Just below the mouth of Pipestone Creek, white clayey sandstone, with reddish bands of ironstone, belonging to the Edmonton subdivision of the Laramie, were first seen. At the water's edge a seam of coal crops out. Two miles up the Pipestone, the beach is still composed of similar sandstone and of whitish sandy shales in which fragments of Dinosaurian teeth and bones and silicified wood were found. Still further up on this stream, where the Bigstone joins it from the south, the light-coloured clays and sandstones are seen to be gradually overlain by the olive sandy shale and brownish-yellow sandstones of the Paskapoo series, these latter sandstones often containing large nodules of limestone, which would, doubtless, burn into a very good lime. The coal seam outcropping on the Red Deer and Saskatchewan rivers, at the bottom of the Paskapoo series, was not seen here, and it is possible that it has thinned out locally, but it is more probable that its outcrop is silted over with white clay, or overgrown with grass or brush, and that, on closer examination, it will be found in this vicinity as well as both to the south and north. Above the mouth of Bigstone Creek, the valley is shallow, with sloping sides, and very few exposures are seen except of boulder-clay. The exposures that do occur consist of light-grey and yellow soft sandstone and sandy shale, which may belong either to the top of the Edmonton, or to the bottom of the Paskapoo series.

Pebble bed.

Pipestone Creek.

Probable coal horizon.

On Bigstone Creek, close to its mouth, the following section of Paskapoo beds is exposed :—

Bigstone Creek.

	FEET.	INCHES.
Soft yellowish-grey sandstone	6	0
Olive sandy shale with friable nodules of ironstone	8	0
Olive and grey jointed sandstone	6	0
Band of hard, compact sandstone	0	6
Friable masses of ironstone mixed with olive shale	0	6
Grey and olive sandy shale and soft sandstone	12	0
Covered	5	0
Hard, grey, compact, calcareous sandstone, breaking off in large angular blocks	4	0
	42	0

A mile further up this creek, the valley is very narrow and a hundred feet deep, exposing eighty feet of grey and olive soft sandstone and of olive sandy shale containing thin bands and nodules of ironstone, and towards the top, beds of harder sandstone. Along the creek up to its source in Bear Lake, exposures of the underlying rocks are very rare, and the shores of the lake itself are low and swampy.

Peace Hills. In the Peace Hills, some very good sections of the superficial deposits are seen. In one case, the side of a knoll has been washed away, exposing thirty feet of horizontally bedded light-yellow sandy boulder-clay, containing pebbles and boulders of quartzite and gneiss, representing the upper boulder-clay, which has been laid down in greater thickness than usual, and afterwards partly eroded away, leaving the Peace Hills, as they now are, a mass of irregular hills and broken ridges.

Battle River below Pipestone Creek. Below the mouth of Pipestone Creek, the sides of the valley of Battle River are mostly sloping, grassy on the north side, but the south side is wooded with poplar and occasional groves of birch and spruce. Scarped banks of whitish sandstone and shale streaked with thin beds of lignite and clay ironstone are also occasionally seen, the whole overlain by a bed of quartzite pebbles.

Dried Meat Lake. Five and a half miles below Battle River Settlement, the river flows into Dried Meat Lake, having first skirted along its northern edge for a mile and a half. This lake is an expansion of the river which spreads from side to side in the bottom of the valley, here from one hundred and fifty to three hundred feet below the plain. The north-east side of the valley is occupied by open poplar bush, while to the south-west the poplar is much thicker, and spruce is also occasionally seen. Where the rock is exposed, it is white clayey sandstone and sandy shale, with thin beds of ironstone. Above the south end of the lake, the following section was measured:—

	FEET.	INCHES.
Concealed	100	0
White sandstone	35	0
Carbonaceous shale	0	9½
Lignite	1	9
Lignitic shale	0	11
White sandstone and shale	70	0
	208	5½

Low escarpments of the white sandstone of the Edmonton series occur at intervals close to the bend of the stream, and twelve miles below the southern end of the lake, a seam of coal crops out at the water's edge, two feet ten inches thick, overlain by sixteen inches of brown lignitic shale, under fifteen feet of white clayey sandstone. The coal seam runs along close to the edge of the water for a short distance. Six miles further down the river, the following section is seen:— **Coal seam.**

	FEET.	INCHES.
Whitish clayey sandstone	60	0
Two thin seams of *lignite* separated by eighteen inches of shale	2	0
Whitish sandy shale	14	0
Coal	3	4
Clayey sandstone and sandy shale	120	0
	199	4

From here to the mouth of Meeting Creek, a distance of eight miles, Battle river winds in a valley a mile wide and two hundred feet deep, the west side being mostly timbered, the east side either grassy slopes or bare banks of sandy clay reddened by the cinders that have been washed down from the burnt coal above. These red cinders also form layers in the bottom of the valley, interstratified with the alluvial sand and clay to a depth of twenty feet, and buffalo bones are found in the alluvium to a depth of fifteen feet.

Meeting Creek has its source in some small lakes west of Todd's crossing of the Battle River, and flows south of east to join the latter stream. In its banks, composed of white clays and sandstones, the following section is shown, two miles above its mouth:— **Meeting Creek.**

	FEET.	INCHES.
Whitish clayey sandstones and sandy shales, the above portion containing many ironstone nodules and large masses of ferruginous sandstone of a bright-yellow or red colour	50	0
Carbonaceous shale	0	8
Coal, compact	4	6
Fine dark clay-shale	9	0
Whitish sandstone	50	0
	114	2

A proximate analysis of this coal, by Mr Hoffmann, gave:—

Hygroscopic water	11·68
Volatile combustible matter	35·82
Fixed carbon	49·88
Ash	2·62
	100.00

The general character of the seam is very similar to that cropping out on Knee Hills Creek, which is described on page 73 E.

A mile and a half further up the valley, the same seam is seen exposed eight feet above the water, and allowing the creek a fall of ten feet in that distance, which is probably more than it actually has, the beds would have a dip up-stream of twenty-seven feet to the mile, and drawing a straight line from this point to "the Maples" on Battle River, the place where this seam first crops out, and which is on about the same level, the strike of the beds is shown to be N. 20° W. For ten miles further up Meeting Creek, similar sandstones and shales are exposed, forming high "bad-land" banks; then the valley becomes much shallower, and the sides more sloping and grassy.

Battle River below Meeting Creek. Below the mouth of Meeting Creek, for fifteen miles, the valley of Battle River continues well defined and about two hundred to two hundred and fifty feet deep, similar whitish sandstones being exposed at intervals all along the banks. In one place, eleven miles from Meeting Creek, the coal seam is well exposed one hundred and eighty feet above the water, showing the following section:—

	FEET.	INCHES.
Black and brown shale	0	3
Coal	0	6
Shale and clay	0	3
Coal	4	6
Shale	1	0
Coal	0	9
	7	3

Underlain by soft white sandstone and overlain by grey clay-shale.

Four miles further on, the following section is exposed:—

	FEET.
Seam of burnt coal	..
White sandstone	30
Brownish banded sandy shale	50
Covered	30
Dark sandy shale	50
White nodular sandstone, at water's edge	..
	160

A mile and a half further down the valley, in one of the ferruginous nodules in this latter layer, *Placenticeras placenta* was found, and the bottom of the bed, which is ten feet thick, is a broken mass of shells of an *Ostrea*, mingled with *Cyprina ovata* and thick calcareous tubes, possibly of *Teredo*. This is the highest bed that can be definitely determined as belonging to the Fox Hill and Pierre group, and as shown in the last section, it lies one hundred and sixty feet below the coal seam which is seen cropping out on the sides of the valley for twenty-five miles. This is the exact thickness given by Mr. McConnell* for the beds between the coal seam and the top of the Fox Hill and Pierre group on the Red Deer River, and there is little doubt but that it is a continuation of the latter seam, which he identified with the seam cropping out at Blackfoot Crossing on the Bow River. Top of Pierre group.

Associated with the bed of fossiliferous sandstone, is a thin bed of limestone in which excellent examples of "cone-in-cone" structure are seen. This is close to the mouth of Paint Earth Creek, and here the valley is very wide, steep escarpments of white clayey sandstone being seen about two miles to the south of the river. From the mouth of Paint Earth Creek to the Elbow, a distance of twenty miles, the sides of the valley are sloping and grassy, or wooded with balsam poplar, and some spruce. A few low exposures of greyish-green and brownish sandy shale and nodular sandstones occur at the bends of the stream, though near the Elbow these are underlain by dark-grey clay-shale. Twelve miles above the Elbow, at the foot of one of the steeper banks, the following fossils were found in the brownish sandstone, viz.:— *Placenticeras placenta, Ostrea subtrigonalis*, a very large *Ostrea*, somewhat like *O. glabra* but possibly new, *Solecurtus occidentalis*, n. sp., and *Cyprina ovata*. Two miles above the Elbow a small stream flows in from the south-west, and at its mouth a rounded butte rises about two hundred and thirty feet above the level of the flat exposing the following section:— Pierre fossils.

*Geol. Survey Report for 1882-4, p. 26 C.

	FEET.
Light grey soft sandstone with included lenticular concretions of ironstone, in which are found fragments of *Placenticeras placenta*, and in the same beds *Protocardia borealis* was also found	130
Covered	20
Dark crumbling clay-shale	50
Covered	20
	220

Pierre fossils. Along the lower part of this stream the banks for five miles are very steep, two hundred feet high and considerably covered with spruce. They are seen to be composed of dark clay-shale, underlain by brownish sandstone containing nodular masses of ironstone along with well preserved specimens of *Protocardia subquadrata*, *Liopistha undata*, *Panopæa subovalis*, burrows of a species of *Teredo* or *Turnus*, and *Baculites compressus*. Above this the banks become sloping and grassy for several miles, and then the white-banded sandstones of the bottom of the Laramie appear in a mass of naked cliffs at the top of a slope towards the north. On the banks of a southern branch of this stream, numerous exposures of boulder-clay were seen overlying the dark clay-shale. The stream is blocked by a great number of beaver dams, many of them newly built.

Elbow of Battle River. At the Elbow, a small stream joins the river from the south. The banks are three hundred feet high, the upper twelve feet being the upper light-coloured boulder-clay, underlain by forty feet of grey shale and ten feet of yellowish soft sandstone. The rest of the bank, with the exception of a bed of dark clay-shale at the bottom, is covered with land-slides.

From the Elbow the river turns and runs north-eastward for sixty-three miles to the mouth of Grizzly Bear Coulée. In the first two or three miles of this distance, low outcrops of dark-grey shale occur, and four miles below the Elbow there is an exposure, from the edge of the river up, of thirty feet of light-grey sandstone, representing the top beds of the Belly River series, overlain by the dark-grey Pierre shales. Belly River series. This bed of light-grey sandstone, often including bands of sandy ironstone, is seen to rise gradually in the sides of the valley as the river is descended. The sides of the valley are abrupt and steep up to the top of the sandstone, but above it they slope up gradually to the level of the prairie, which is two hundred and fifty to three hundred feet above the river. These banks are very similar to those of the Red Deer River near Hunter's Hill, where the Pierre shales are seen to occupy the surface of the country, which gradually slopes down to the brim of the Red Deer valley, and the valley is then cut down

several hundred feet through the white sands and clays of the Belly River series.

For fifteen miles above the mouth of Iron Creek the valley is wide and open, with sloping grassy sides, in which, however, a few low exposures of white and yellow sandstone crop out close to the edge of the water, while back from the river the flats are occupied by hillocks of loose yellow sand, thirty to fifty feet high. At the mouth of Iron Creek the flat is underlain by a bed, six feet or more in thickness, of coarse gravel. The Iron Creek valley for six miles upward from Battle River is very wide, and full of sandy hills, while for eleven miles further it is well defined and a hundred feet deep. In the sides in this distance no exposures of the underlying rocks occur, but in most places yellow unstratified sand appears to cover them from top to bottom, except for the last two or three miles, where as much as twenty-five feet of sandy clay containing pebbles of quartzite and gneiss, are seen at the edge of the creek, representing in all probability the lower boulder-clay.

Sandy hillocks.

Iron Creek.

Near the crossing of the old trail from Victoria to the plains to the south, twenty feet of light-grey and yellowish, somewhat clayey, soft sandstone and grey sandy clay-shale including beds of brown ironstone, are seen in the side of the valley, at an elevation of 2,090 feet above the sea. For six miles further up the creek, horizontal, soft, whitish or light-grey sandstone with yellow iron-stained beds and bands of laminated ferruginous sandstone and numerous nodules of yellow ironstone, crop out to a height of ninety feet above the bottom of the valley. In one place a large number of fragments of fresh-water fossils, such as *Unio*, *Sphærium* and a gasteropod like *Campeloma producta* were collected from the ironstone nodules. These sandstones and clays represent the upper part of the Belly River series, and lie on the western side of the wide anticlinal which brings this formation to the surface. Along the creek up to its source in Wavy Lake, at an elevation of 2,260 feet, a distance of twenty miles, the country is undulating and the soil is sandy, but no trace of the underlying rocks is to be seen, though on the ridge west of Wavy Lake a dark clay washes from the side of the hill, very like the clay derived from the degradation of the Pierre shales.

Light-grey sandstone.

It was close to this creek that the mass of meteoric iron now in the museum of Victoria College, Cobourg, was found by the late Rev. George McDougall.*

Meteoric iron.

The Battle River valley for five miles below Iron Creek is very wide and often dotted with sandy knolls, one of which was found to be one hundred and fifty feet high, and composed of

* See note by Dr. A. P. Coleman in Trans. Royal Soc. Can., 1886, Sec. III., p. 97.

loose yellow sand scattered over with pebbles of quartzite and gneiss, among which a few rose-bushes and trailing junipers manage to live. Thence to the mouth of Grattan Creek, a distance of nine miles, low outcrops of horizontally bedded light-grey and yellowish, rather soft sandstone interbedded with hard ferruginous sandstone, appear at intervals, close to the edge of the water. But much better sections of these sandstones of the Belly River series are to be seen in Grattan Coulée. In this valley, three miles above the mouth of the creek, the following section was obtained on the south bank:—

Grattan Creek.

	FEET.
Loose sand containing towards the top a large number of boulders of gneiss and a few of quartzite	25
Soft yellow sandstone, with a layer of yellow ironstone and some harder sandstone containing fragments of silicified wood	10
Yellowish soft sandstone, with a three-inch bed of broken lignite associated with a layer of soft plastic clay. Scattered through the sandstone are many brown, dark-weathering nodules of ironstone	40
Rather clayey, yellowish-white, soft sandstone	20
Covered (down to the water)	75
	170

Up the same valley for a distance of eighteen miles bad-land banks of soft whitish and yellowish clayey sandstone, to a height in many places of a hundred feet, form its sides till the level of the prairie is reached, at an altitude of 2,210 feet above the sea. No fossil remains have been found in these beds, except a few broken fragments of bone and silicified wood, but there can be no doubt that their position is near the top of the broad anticlinal which runs northward past the Neutral Hills and below the Pierre shales. They present the characters of both the white and yellow subdivisions of the Belly River series, though the white sandstones here underlie the yellow, and, further east, either change their character and become less clayey, or disappear under the overlying yellow beds, though these latter do not immediately underlie the Pierre on the western side of the anticlinal.

On Battle River, between the mouths of Grattan and Buffalo creeks, the valley is narrower than usual and much more thickly wooded, only two or three exposures of hard yellow sandstone being seen on its sides. A mile above Buffalo Creek, however, the following section was seen:—

	FEET.
Shaly sandstone	3
Light-coloured brownish yellow sandstone with nodular layers of calcareous clay ironstone containing traces of fossil leaves	7
Ferruginous sandstone breaking, when struck, into small, irregular fragments	3
Soft grey shaly sandstone	7
	20

Turning up Buffalo Coulée, the banks for the first eighteen miles are composed of greyish-yellow soft sandstone with bands of yellow ferruginous sandstone. Further up, where the creek expands into a small lake, a seam of lignite ten inches thick crops out underlain by six inches of brown lignitic shale between beds of soft, thick-bedded, whitish-yellow sandstone. This seam represents all the coal at present known to occur in the Belly River series in this vicinity. Further up the coulée some small exposures of soft and hard yellow sandstone are seen near the crossing of the telegraph trail, very similar in character to those already described. Buffalo Coulée.

From the mouth of Buffalo Creek for twelve miles north-eastward to the mouth of Grizzly Bear Creek, the Battle River valley is more open than in the previous stretch. The sides are from two to three hundred feet high, but are generally grassy, and very few small croppings of yellowish sandstone reveal the character of the underlying rocks. In Grizzly Bear Coulée from its mouth upwards, rocks distinctly characteristic of the Pierre are met with, dark-grey crumbling clay shales holding numerous crystals of selenite and rounded nodules of ironstone, while three miles above the mouth of the coulée, in a small branch coulée and at a height of two hundred and twenty feet above Battle River, a fragment of a *Baculites* was collected from these dark shales. Grizzly Bear Coulée.

For fourteen miles below the mouth of Grizzly Bear Coulée, as far as the last easterly bend of the river within the district, yellow, often lamellar sandstone with intercalated bands of ferruginous sandstone, may be seen cropping out in low exposures close to the water's edge. At the above mentioned bend, hard brown sandstone appears just below high-water mark, and blocks of similar sandstone are scattered along the edge of the stream. This sandstone, though overlain by a considerable thickness of Pierre shale, is essentially similar to the sandstone of the Fox Hill group, and contains the following species of fossils :—*Cyprina subtrapeziformis*, n. sp., *Modiola*, sp., *Pteria linguiformis*, var. *subgibbosa*, *Tancredia Americana*, fragment of an *Anisomyon centrale ?*, *Astarte*, sp., *Ostrea glabra ?*, *Lunatia concinna*, and burrows of *Teredo* or *Turnus*. Four miles east of the bend, sixteen feet Hard brown sandstone.

of light-yellowish sandstone is exposed above the water, overlain by dark-grey clay shale containing fragments of shells of *Gervillia*, while seven miles further east there is, close to the water, a low exposure of sandstone similar to the last, over which are fifteen feet of dark clay-shale holding shells of *Baculites*, and above for eighty feet up the bank, slides of similar shales are seen. Five miles further, or two miles above the mouth of Ribstone Creek, these dark Pierre shales come down to the water's edge, and from there to the crossing they form the sides of the valley from top to bottom.

Ribstone Creek. We shall now turn to examine Ribstone Creek, which flows into Battle River from the south, three and a-half miles west of the crossing of the Fort Pitt trail. The valley for the first three miles is wooded, and the rocks are everywhere covered with earth-slides. Then in the bottom of the valley which is one hundred and sixty feet deep, there are exposed sixty feet of horizontal, yellowish, rather hard, false-bedded sandstone containing ironstone in beds and irregular nodules. This layer of coarse grained yellow sandstone continues up **Hard yellow sandstone.** the creek for three miles till it disappears under the bed of the stream, which rises sixty-five feet in the same distance; but northward it probably changes into a sandy shale, as there is no trace of such a bed of compact sandstone to be seen in the valley of Battle River. Half a mile above where the sandstone is last seen in the bottom of the valley, there is a cut bank, thirty feet high, showing at the top yellowish-grey sandy shale, which is underlain by dark-grey clay-shale holding ironstone nodules in which *Inoceramus Sagensis* was found. From this point, for fifty-five miles up the creek, or thirty-four miles in a straight line S. 47° W., the valley is at times very wide, with marshy flats, and at times the sides are much more abrupt, but nowhere are the underlying rocks to be seen, the country being covered with a thick **Sandy knolls and ridges.** deposit of loose yellow sand, which is either piled up in irregular shifting knolls, or in long ridges lying more or less north and south. It is possible, however, that these ridges or higher points of the country, have a core of the underlying rocks which, in all probability, is composed of easily disintegrated, yellow sandstone, from which the surrounding sand has been in whole or in part derived, but whether in that case the sandstone would lie at the bottom of the Pierre, or belong to the yellow part of the Belly River series, it is impossible to say. At the point which we have reached, there is a hill on the east side of the valley which shows a section of fifty feet of light-grey, soft, clayey sandstone, with many yellow bands, and with seams of nodular black-weathering ironstone belonging, undoubtedly, to the **Sandstones of Belly River series.** Belly River series. Twenty-four miles east of this, on the trail from Fort Pitt to Sounding Lake, there are some low exposures of

similar sandstone and ironstone belonging to the same horizon. Following the creek for four miles further, we come to another exposure of twelve feet of similar light-grey soft sandstone including beds of brown nodular ironstone, overlain by light-grey plastic clay-shale. South of the hill in which this section occurs, the creek flows northward for several miles between sandy banks which rise gradually for some distance on either side into considerable ranges of hills. To the south of the most westerly of these ranges, the creek has worn out a wide valley, leaving the southern faces of the hills often scarped and bare, but unfortunately too much obscured by land-slides to allow of the satisfactory tracing out of the different beds without very great difficulty and expenditure of time. These hills are very hummocky, and are in many places covered with pebbles and large boulders of quartzite and gneiss. As the rocks, where seen, were dipping in different directions and at various angles, there can be little doubt that these rough hills have been formed by masses breaking from the face of the higher table land—which now remains as a slightly elevated central axis—and sliding over some of their constituent beds of soft unctuous clay down to the lower-lying country, where they rest as irregular knolls and hummocks that soon become rounded off by atmospheric erosion. The rocks are, like those last seen, light-grey clayey sandstones holding in one place a thin seam of lignite, and containing throughout nodules of black-weathering ironstone, in which are often included traces of woody fibre and pieces of beautifully silicified wood. In one place a layer of small pebbles was also seen, accompanied by a boulder of gneiss fifteen inches across and five inches thick. This sandstone is overlain throughout by a layer of dark-grey Pierre shale containing numerous crystals of selenite. The covering of shale prevents the hills from being worn down by atmospheric erosion as fast as the more sandy parts of the surrounding country.

The valley, however, is wide, with clay-flats stretching along either side of the creek, as far as the point where it cuts through the ridge which runs northward from the "Nose." Here there is an exposure of eight feet of light-brown soft sandstone, underlain by twenty-five feet of dark-grey clay-shale including nodules of brown ironstone, holding *Placenticeras placenta*, *Baculites compressus* and *Liopistha undata*. This is the same section mentioned on p. 82 E, in the description of the Neutral Hills, as being at least six hundred feet below the top of the Pierre, and as about three-quarters of a mile further east these shales are seen to rest on whitish clayey sandstones, we have here, doubtless, the bottom of the Pierre and the top of the Belly River series. **Junction of Pierre and Belly River beds.**

The last tributary of Battle River included in the area of the accompanying map, is Blackfoot Creek, which rises to the north-east of the **Blackfoot Creek.**

Blackfoot Hills, and, after a course of thirty-five miles, flows into Battle River just below the crossing of the Fort Pitt trail. In this valley, which is very deep towards its mouth but gradually flattens out towards the north up to the marshy lakes of which it is the outlet, only a very few exposures of the underlying rocks are seen, and these are dark-grey clay-shales with ironstones nodules, quite typical of the Pierre. The shales are overlain by a sandy clay or sand, and the hills are covered with gneissoid boulders.

Country lying between the North Saskatchewan and Battle Rivers.

In this district, the exposures of the underlying rocks are very few; even where they do occur, they are slight and indefinite in character, and to all appearance, the bedding is perfectly horizontal. Fossils, too, even in beds such as the typical shales of the Pierre in which, a little further south, they are found in such profusion, are here almost entirely wanting, so that we can only assume that we are in the main correct in our determination of the position of the beds, and that the boundary lines of the formations, as laid down on the map, are approximately accurate.

White Mud Creek.

Towards the west, croppings of light-grey clays and sandstones with included nodules of ironstone of the Edmonton subdivision of the Laramie are found on White Mud and Black Mud creeks, and a coal seam also appears a mile and a-half below the trail crossing of Black Mud Creek. From here eastward, no rocks were seen in place till Beaver Creek was reached, the intervening country being occupied by the "Beaver Hills," with their low marshy tracts and lakes. These hills have already been described on p. 43 E of this report; we shall only add that they are composed entirely of superficial deposits of sand and sandy clay mixed with gravel, though it is probable that these deposits are laid down on a slightly elevated ridge of Laramie sandstone. Wherever sections of the drift were seen, as on Hastings' and Katchemut's creeks, it consisted of horizontally-bedded, hard grey sandy clay, containing numerous quartzite pebbles, though on their surface the knolls and ridges are covered with a slightly sandy clay derived, no doubt, from the wearing down, and perhaps redistribution, of the underlying drift On the east side of the hills, however, there are some patches of white clay covered in places with a saline efflorescence, indicating the presence in the immediate vicinity of the white clays of the Edmonton series. On the east side of township 48, range 18, indications of coal, doubtless of Laramie age, are seen just south of the

Beaver Hills.

telegraph trail, and on Beaver Creek, eight miles above where it flows into Beaver Lake, in section 5, township 50, range 18, there is an exposure, of the same age, of eight feet of whitish clayey sandstone, interstratified with beds of light-grey clay-shale and a bed of yellow sandy ironstone. Six miles further down the same creek, another low exposure of similar rock occurs.

Beaver Lake has low-lying shores, which show no signs of bedded rock; the beach consists of coarse grey sand, behind which is a pile of large boulders of gneiss and quartzite. which are constantly shoved back by the expansion of the ice in the winter and by its force when the water dashes it against them in the spring. On Beaver Creek, where it flows out of the north end of Beaver Lake, the banks are low and generally grassy for nine miles, then at a sharp bend in the stream, soft light-grey shale appears close to the water, and from this point to the crossing of the Victoria trail, horizontally-bedded, light-grey clayey sandstone and clay-shale with irregular nodules of calcareous ironstone and some bands of yellow ferruginous sandstone, crop out in low exposures along the channel of the creek. Near the trail crossing, there is a bed of bluish-grey friable clay-shale holding large lenticular masses of ferruginous sandstone and fragments of coal, the latter, not in any connected bed, but consisting of the carbonised trunks of small trees lying separately. This dark clay-shale soon changes, however, to a rather light-grey, sandy clay-shale including a nine-inch seam of coaly shale. For the rest of the distance to its mouth, the creek flows through swamp and thick scrubby forest, its banks being low, showing, for half a mile, light-grey sandstone and shale, and below that, light-coloured boulder-clay, or fine-grained bedded silt.

Beaver Lake.

Light grey clayey sandstone.

The whitish sandstones and clays seen along this creek belong, undoubtedly, to the Edmonton subdivision of the Laramie, and though the shales at the crossing look much more like Pierre than Laramie, still the stratigraphy appears to connect them rather with the latter, and in the absence of all traces of fossils, it is not deemed advisable on such slight evidence to record the Pierre as occurring here.

Laramie sandstone.

About eighteen miles east of Beaver Lake is Vermilion River, which rises near the old location of the Canadian Pacific railroad at an elevation of about 2240 feet. Flowing at first northward in a slight depression in the plain, it soon developes a definite channel, the sides of which show light-coloured, bedded sandy clay containing a few pebbles. In the north-western corner of township 49, range 15, the underlying rock first appears in a low exposure of dark-grey clay-shale containing minute crystals of selenite, while a short distance further down the creek, light-grey, similar clay-shales are seen, including large irregular brown-weathering nodules of calcareous

Vermilion River.

ironstone, sometimes vesicular and holding numerous impressions o plant fragments. For about eight miles down the river, this clay-shale with ironstone, which, no doubt, represents the lower part of the Pierre shales, crops out in the banks at short intervals, and then, for six miles, the banks are grassy or show only small sections ot superficial sand or clay.

Pierre shales.

About the centre of township 52, range 14, clay-shale again crops out, associated with beds of ash-grey lamellar sandstone, and including nodules of calcareous ironstone, containing impressions of leaves, among which were *Podocarpites, Tyrrellii* and *Trapa borealis.* The latter species has, up to the present, been found chiefly in beds of the Edmonton series, but Sir J. W. Dawson states, with regard to it, that it "is associated, at several localities, with *Pistia* and *Lemna,* and in this respect, the beds holding it conform in their flora to the Belly River series on the South Saskatchewan." In the present instance, considering what we know of the surrounding strata, it is highly probable that the beds here exposed belong to the Belly River series, and lie on the northern extension of the low anticlinal which has been traced from the South Saskatchewan northward across Battle River.

Belly River series.

Following the river still further to the north, we pass through a wide, sloping, grassy valley, the surface being composed of fine-grained bedded clay, underlain by a sandy boulder-clay, till the river turns sharply eastward, and enters the "Chain of Lakes," a series of marshy lakelets which occupy the bottom of the valley for eighteen miles, and are imperfectly separated from each other by stagnant, sedgy creeks; the surrounding hills are covered with grass or small timber.

"Chain of Lakes."

Two miles below the most easterly of the lakes, there is a low exposure of Pierre-like shales, including nodules of ironstone, and seven miles further down the stream and a mile and a half south of the fourteenth Base Line, rather hard yellow sandstone is seen in the hill-side, one hundred and twenty feet above the river, while in the bottom of the valley the following small section is exposed :—

	FEET.	INCHES.
Light-grey sandy shale	12	0
Light-grey soft sandstone	2	6
Dark-grey sandy shale containing traces of fossil plants	5	0
	19	6

Five miles further down the river, in which distance, only low croppings of shale or sandstone are seen, the following section is exposed with a light, but decided, dip up-stream :—

	FEET.	INCHES.
Light-grey soft clay-shale	2	0
Grey clay-shale, friable and rather carbonaceous at the top, interbedded with thin layers of olive sandstone	5	8
Dark-grey slaty carbonaceous shale with obscure impressions of plants, and showing in many places incipient concretions or concretionary rings	3	0
Olive-green soft sandstone containing a few nodules of ironstone and obscure carbonised impressions of plants	4	0
	14	8

Below this exposure, no rock is seen in place along the river till near the mouth of Birch Creek; the bottom of the valley is of hard clay, and its sides show white and light-grey clay and dark brown-weathering ironstone, which have every appearance of having been derived from the white beds of the Sub-Pierre.

Two miles above the mouth of Birch Creek, however, thin bands of hard and soft yellow sandstone project from near the bottom of the bank. On Birch Creek itself, nothing is seen but dark-grey sandy boulder-clay. Around Birch Lake, the banks are generally sloping and grassy or lightly covered with brush, but at the northern extremity of its eastern arm, there is an abrupt escarpment, showing fifty feet of horizontal yellow soft sandstone interbedded with thin bands of similar but harder rock, and in a small island, half a mile from shore, sixty feet of similar rock are exposed. This is, without doubt, the same band of yellow sandstone which is exposed at intervals on Battle River above the mouth of Grizzly Bear Coulée, and on Ribstone Creek a short distance above its mouth, and which was there seen to underlie a considerable thickness of true Pierre shales. On Vermilion River, also, three miles below the mouth of Birch Creek, there is an exposure of forty feet of similar soft yellow sandstone, with large nodules or concretions of ferruginous sandstone throughout, but still doubtless belonging to the same band as that seen on Birch Lake. As these two places differ in altitude three hundred feet and are fifteen miles apart, the dip of the rocks is shown to be twenty feet in the mile toward the east. Following northward for a mile the small brook at the mouth of which this exposure occurs, we gradually rise through beds of apparently horizontal sandstone, till they are seen to be overlain by beds of dark-grey clay-shale, beyond which the sides of the little valley become sloping and grassy. In the valley of Vermillion river, below the mouth of this small tributary, similar sandstones crop out for a distance of

Birch Lake.

Yellow sandstone.

Easterly dip of rocks.

two miles and a quarter before they are carried beneath the level of the water by the low easterly dip, and the bank is then composed entirely of yellowish-grey friable clay-shale. For five miles further down the valley, small croppings of similar shale appear in low escarpments, and at the end of that distance, there is a slight exposure showing at the top, soft, yellow, thin-bedded sandstone underlain by dark-grey, sandy shale, with beds of nodular ferruginous sandstone. For the next fifteen miles, the valley is from one hundred to one hundred and fifty feet deep, with sloping banks wooded on the south side, but open and grassy on the north side. No rock was seen in place, though fragments of yellow lamellar sandstone, doubtless derived from rocks immediately underlying, were scattered about the face of the bank. At the end of the fifteen miles, a ledge of similar sandstone was seen cropping out in a small lateral coulée at the top of the bank. From this point down to the confluence of the Vermilion and North Saskatchewan rivers, the valley maintains very much the same character as before, the sides being sloping, and either grassy or wooded and often scattered over with a few large gneissoid boulders. In many places there are indications of underlying clay-shale, and thin beds of sandstone are sometimes seen, either projecting as ledges from the side of the hill, or in detached blocks on its face. No fossils were found till the mouth of the stream was reached, where a hundred feet of dark-grey clay-shale is exposed, holding crystals of selenite and numerous ironstone nodules from which the following fossils were collected:—*Baculites ovatus*, *B. compressus*, *Inoceramus Sagensis*, *I. Vanuxemi*, and an undescribed *Periploma*.

Lower portion of Vermilion River.

Fossils.

North Saskatchewan River.

The North Saskatchewan is a glacier-fed river, rising in the axial range of the Rocky Mountains, and flowing eastward across the northern edge of the Great Plains, after joining the South Saskatchewan, it debouches as the Saskatchewan into the north-western angle of Lake Winnipeg, from which it flows as the Nelson River, north-eastward into Hudson's Bay. The most part of its upper course is as yet unexamined geologically, but in the vicinity of Rocky Mountain House where our examination of it began, the rocks belong to the Paskapoo subdivision of the Laramie, and are composed of horizontal, slightly yellowish-grey, thick-bedded, massive, and generally hard sandstones, though with occasional softer bands. At the mouth of the Clearwater the following section is well exposed:—

Rocks at Rocky Mountain House.

	FEET.	INCHES.
Yellowish-grey, rather hard thick-bedded sandstone.	20	0
Bluish-grey sandy shale, often with a semi-conchoidal fracture, and holding traces of fossil plants...	20	0
Coal	0	8
Light grey compact sandstone	2	8
Coal	0	3
Carbonaceous shales	0	2
Coal	0	8½
Carbonaceous and sandy shale	2	0
Bluish-grey slightly sandy shale holding traces of fossil plants	2	0
	48	5½

The coal collected from the above section was examined by Mr. Hoffmann, and pronounced by him to be a lignitic coal, which, when freshly mined, would doubtless bear transportation, and is a tolerably firm fuel.

For fourteen miles up from its mouth or below the confluence of Askowi Creek the Clearwater River was not examined, the trail which was surveyed by Mr. Hamilton, my assistant, in 1885, keeping on the higher ground to the east, but Dr. Hector ascended the stream on the ice in the winter of 1858, and writes of it as follows: "The banks of the river were high and steep, and present sections of the argillaceous sandstone, sometimes forming very picturesque and ruinous cliffs which peep out from among the dark green pines." * Clearwater River.

Above Askowi Creek, the channel of the river is wide and very much obstructed by gravel bars. On one side of the stream, as far as the eastern base of the foot-hills, there is constantly a wide flat underlain by a thick deposit of quartzite shingle, while opposite it at the outer bends of the stream, the low hill-side is scarped, showing sections of horizontally bedded, light bluish-grey, rather hard coarse-grained sandstone. In the valley of Prairie Creek, a small tributary of the Clearwater from the west, similar sandstone is exposed in many places east of the Stoney Indian pack trail. Prairie Creek.

On the west side of the North Saskatchewan, to which we now return, and two miles below the mouth of the Clearwater, a seam of coal crops out close to the water's edge; the bank here is low, and covered with a deposit of quartzite shingle. Only the following section was here exposed:

	FEET.	INCHES.
Light-grey clay-shale containing obscure fragments of plants and numerous erect silicified stumps of trees, some of which, however, are turned into coal for a couple of inches around the outside	3	0
Coal	0	5
Grey clay-shale	0	8
Coal (at the water's edge) reported as about	2	0
	6	1

* Journals, Detailed Reports and Observations relative to the Exploration by Captain Palliser. London, Government, 1863, p. 75.

Coal seam.

This is undoubtedly the same seam as that seen in the cliff at the mouth of the Clearwater, though here it has become very much thicker and more compact. Coal was formerly obtained from this place by the servants of the Hudson's Bay Company, and used by them at the forge at Rocky Mountain House. It is a coal very similar to that obtained at Lethbridge, on the Belly River, and will keep for a length of time exposed to the air without crumbling, as large masses of it scattered along the banks of the river for many miles below its outcrop, and in some cases rounded off by the action of the water retain all their firmness.

The following is Dr. Harrington's report on specimens brought from this seam by Dr. Selwyn, in 1873 :—

Analysis of this coal.

"A bright black coal, breaking with angular fracture and giving a brick-red ash. Two proximate analyses by slow and fast coking gave—

	Slow coking.	*Fast coking.*
Water	7·82	7·82
Volatile combustible matter	31·35	38·00
Fixed carbon	54·97	42·25
Ash	5·86	5·93
	100·00	100·00"

Specimens from the same seam were collected by the writer in 1886, and analysed by Mr. Hoffmann, with the following result:—

	Fast coking.
Hygroscopic water	7·01
Volatile combustible matter	34·63
Fixed carbon	50·34
Ash	8·02
	100·00

The coke is non-coherent.

On the west side of the river the banks are high, and consist of yellowish-grey, coarse-grained sandstones, generally thick-bedded, but occasionally lamellar. Half a mile below the coal seam, thin bands of conglomerate with quartzite pebbles and a three-inch bed of limestone, are also seen, in the latter of which were found numerous remains of leaves of *Sequoia Langsdorffii*, Heer; *Sequoia Couttriæ*, Heer; *Carya antiquorum ?* Newberry; *Salix Laramiana*, Dawson; *Nelumbium Saskatchewense*, Dawson; *Sapindus*, allied to *S. obtusifolius*, Lesq.; and species of *Populus, Quercus, Ficus* and *Carpolithes* (*Nyssidium ?*).

Fossil plants.

* Geol. Survey Report for 1873-74, p. 63.

Along the river down to within half a mile of the crossing of the eleventh base-line, a distance of ten and a half miles below Rocky Mountain House, the west bank is a low alluvial flat underlain by quartzite gravel and covered, in most places, with spruce of fair size, while on the east side the bank, in a number of places, is high, showing escarpments of yellowish coarse-grained sandstone, apparently horizontal. Here are exposed thirty feet of yellowish-grey hard sandstone, changing gradually into bluish softer sandstone. The river soon turns again to the east side of the valley, leaving alluvial flats on its western bank as far as the mouth of Baptiste River. One and three-quarter miles below where the eleventh base-line crosses, the high-cut banks begin again on the east side, showing the following section:—

	FEET.	INCHES.
Grey and olive sandy shale holding a band of sandstone and nodules of limestone. In one band of lamellar sandstones near the top, specimens of *Sphærium* and *Hydrobia* were found..............	80	0
Coal associated with fragments of silicified wood...	0	2
Sandy shale....................................	20	0
Rather hard sandstone..........................	30	0

From this point to near the mouth of the Baptiste River, twenty-five miles below Rocky Mountain House, similar sandstones and shales continue along the eastern bank, while the west bank is low and underlain by quartzite gravel and wooded with spruce and poplar.

Baptiste River, at its mouth, has a channel sixty feet wide, but when seen in September the stream did not average more than twenty-five to thirty feet, and was full of boulders which projected above the water, many being of reddish or dark-brown gneiss from twelve to sixteen inches in diameter. The water is beautifully clear and transparent, though with a slightly brownish tinge. Baptiste River.

Half a mile below the mouth of Baptiste River, in a high cliff on the west bank, thirty feet of coarse-grained, yellow, thick-bedded sandstone is seen underlain by eighty feet of greenish sandy and clayey shale with a thin seam of coal near the top, and a short distance further down the river numerous nodules of limestone occur in the shales.

Three and a half miles below the mouth of Baptiste River, similar sandstones and shales are again seen on the east side of the river, the lower beds being here one hundred feet thick, and as the fall in the river in this distance amounts to about twenty feet, the beds would appear to be quite horizontal, at least, in the direction in which the river is running. A mile further down, the valley widens and the

Expansion of valley.

river winds for two miles through the wide flat which stretches between the steep banks on either side. This flat is underlain by ten feet or more of quartzite gravel covered with a thick bed of fine white silt, the river having evidently at one time expanded here even into a small lake, which, however, it has now drained by cutting through the band of hard sandstone that had dammed it back. Below this expansion the valley for two miles is narrow, with steep sides of olive shale and sandstone one hundred and fifty feet high. After this it again spreads out in a circular area about a mile in diameter, below which the stream flows between abrupt walls of hard, yellowish-brown, thick-bedded sandstone, with distinct false-bedding, underlain by grey and olive, sandy shale to the height of one hundred and fifty feet.

High cliffs of hard sandstone.

From this point to the mouth of the Brazeau River, a distance of eleven miles, the valley is very irregular, though the sides are generally high and composed of yellowish-brown sandstone, and of grey and olive sandy shale, but the immediate banks of the river are often much lower, and show sandstones and shales at the bottom, overlain by quartzite pebbles which are again overlain by white silt.

Brazeau River.

Brazeau River is a stream of clear blue water, about as large as the Red Deer, flowing with a current of five miles an hour in a thickly wooded valley 130 feet deep at its mouth. Its bed is covered with rounded pebbles, and along its banks are scattered numerous boulders of gneiss with masses of sandstone, quartzite and concretionary limestone traversed by many thin veins of calcite.

It rises in the Rocky Mountains between the sources of the North Saskatchewan and of the Athabasca, but though its upper course has not yet been explored, it is probable, from the beautiful clearness of the water, that it is not fed by glaciers.

For eleven miles below the mouth of the Brazeau, the North Saskatchewan continues its course to the north, winding from side to side of the valley with an irregular current, at one time quiet and beautifully smooth, at another, rushing over its stony bottom in a series of rough rapids; making an average current in this distance of 4·6 miles an hour. The valley is 150 feet deep, with scarped banks of horizontal, soft light-grey sandstone and olive sandy shale on the outer sides of the bends, and bench land overlain by pebbles and silt on the inside of the curves. At the end of this stretch, the river bends sharply to the right and runs east for eight and a half miles to the mouth of Wolf Creek, which is a stream flowing in from the wooded country to the south, having at its mouth a channel seventy-five feet wide and five feet deep, with a stony bed. The water is brown but clear, and when I saw it in September, did not occupy more than a third of the width of the high-water channel.

Wolf Creek.

Just above this eastward bend in the river, a fine exposure of the rocks of the Paskapoo series is seen in a high cliff on the south-east side of the river, showing the following section :— Section.

	Feet	Inches.
Covered	20	0
Yellow and olive sandy shale	20	0
Irregular bed of hard, bluish limestone, breaking readily with uneven surface. In it were found obscure impressions of leaves and shells	12	0
Yellowish-grey sandstone	3	0
Bluish-grey, slightly sandy clay-shale	2	6
Yellowish-grey, rather harder and more coarse-grained sandstone	16	0
Coaly shale	1	0
Similar, but slightly darker sandstone	20	0
Soft bluish-grey, rather coarse-grained, thick-bedded sandstone, with an occasional harder nodular layer	100	0
	183	6

Some beautifully preserved leaves of *Viburnum asperum* and *Corylus McQuarrii* were collected from a slab of sandstone fallen from the face of the bank.

Between this exposure and the mouth of Wolf Creek, the valley is very irregular, occasional high scarped banks of sandstone and shale standing close to the water's edge, while at other places, wide wooded flats stretch back on either side into deep bays.

At the mouth of Wolf Creek the river turns to the left and flows N. 35° E. for twenty-nine miles, the valley on the whole being rather narrow and thickly wooded. Just below the mouth of the creek is an almost perpendicular bank, 100 feet high, of bluish-grey sandstone and clay-shale often very sandy with a band of concretionary limestone fifty feet from the bottom. A few fragments of fossil wood were collected from the sandstone, along with broken pieces of shells among which only the genera *Viviparus* and *Sphærium* were recognisable.

Seven miles further down the river, a sharp bend in the stream brings us opposite a series of cone-shaped cliffs which were depicted and described by Dr. Selwyn in 1873.* They consist of one hundred and eighty feet of light bluish-grey sandy clay-shale, with bands and nodules of sandstone, overlain by twenty feet of rather hard, yellow thick-bedded sandstone forming a capping to and protecting the top of most of the cones. From these cliffs to a point eighteen miles below the mouth of Wolf Creek, the river winds among a number of low islands, flowing at the rate of three and a half miles an hour. Cone-shaped cliffs.

* Geol. Survey Report for 1873-74, p. 41.

The flats so far have been wooded with black and white spruce, with aspen and balsam poplar in the more open and drier places, but here balsam fir (*Abies balsamea*) of about six inches in diameter begins to appear along the edge of the water.

In this stretch, exposures of similar greenish-grey sandy shale and sandstone continue to be seen in the banks, which are, however, more and more covered by slides of silt and dark-coloured boulder-clay, the boulder-clay often including masses of coal of considerable size.

Coal seam.

Eighteen miles below Wolf Creek, at a slight bend in the river, and in a bank largely covered by slides of the upper superficial deposits, a seam of coal is seen. The whole bank shows a section somewhat as follows, the lower part only being accurately measured:—

	FEET.	INCHES.
Whitish fine-bedded clay	8	0
Dark-coloured boulder-clay	30	0
Covered	12	0
Bluish-grey, greenish-weathering, soft sandstone	10	0
Covered	35	0
Coal	1	6
Black shale	0	2
Coal	1	3
Clay	0	1
Coal	1	10
Shale	0	6
Coal	2	0
Coarse friable sandy shale	1	1
Coal	8	6
Covered to water	12	0
	123	11

the whole lying apparently quite horizontally.

Sandstones and shales.

For three-quarters of a mile below this point, the bank is completely covered with slides, and then horizontal, hard, thick-bedded yellow sandstone is exposed for twelve feet above the water, and a mile further down the stream, ten feet of hard greyish sandstone overlain by thirty feet of bluish and greenish-grey sandy shale and sandstone, apparently horizontal. For several miles beyond this point, the banks, on alternate sides of the river, show grey and olive sandy shale, overlain by dark-grey sandy clay and sand with pebbles, and above these a rather compact bedded sand, with a bed of broken coal sometimes appearing at the top of the shale; the beds lie horizontal, or with a very slight dip up stream. Just below the mouth of a small brook flowing in from the west, eight feet wide and two feet deep, and six miles below the coal outcrop described above, a seam of coal eight

feet thick, doubtless the same seam, is exposed a short distance above the water, in what is, perhaps, a slide from the bank behind, both overlain and underlain by rather hard sandstone. Two miles further down the stream, eight feet of light-grey thick-bedded sandstone is exposed at the water's edge, overlain by sixty feet of bluish and yellowish sandy clay-shale, with a four-foot band of yellow sandstone at the top,—and again, across a bend of the river, a similar section is exposed one hundred feet high, over the face of which fragments of coal are falling from some beds which are covered towards the top. Taking it for granted that the coal seam lies immediately on top of the beds exposed, we would have the base of the seam eighty-eight feet higher above the water than where it is first exposed, and as the difference of level is about fifty-four feet and the distance, in a straight line, six miles, it would leave a south-westerly dip for the beds of five feet eight inches to the mile. **Extension of coal seam.**

From this last exposure, the river turns and describes about three-quarters of a circle with the sun; it then flows east for eleven miles to Goose Encampment, the scarped banks showing the lower bed of hard sandstone gradually rising, with a dip S. 75° W. of sixteen feet to the mile, and a little further on, beds of yellowish-grey sandstone and bluish-grey sandy shale crop out near the water's edge.

Buck Creek. Buck Creek, which empties into the Saskatchewan from the south, eight miles above Goose Encampment, has a channel at its mouth eighty feet wide and four feet deep, though, when examined, the stream was not more than twenty feet wide and six inches deep, the water being of a clear brown colour. Wide gravel bars stretch along the side of the Saskatchewan, and here, as in many other places, hide the mouth of the tributary stream.

Coal seam at Goose Encampment. At Goose Encampment, the river turns again to the north-east, flowing in a very crooked channel for sixteen miles, as far as White Earth Creek. At this bend, a seam of coal is exposed at the edge of the water, no doubt the same seam which is very well exposed a short distance further down the river. In a straight line across country from the place where the last coal seam is first seen, on a bearing S. 75° W., the distance is seventeen miles, and taking the dip given above for this bearing, namely, sixteen feet to the mile, and allowing a fall of one hundred and fifty feet in the river in the distance, we have a thickness of about four hundred feet of yellow and grey sandstone and grey sandy shales between these two coal horizons. As to the thickness of the beds above the upper of these coal horizons, no estimate could be made, the dips being slight and variable, and the character of the beds being so inconstant, that it appears to be impossible to trace them for any considerable distance, even in the same escarpment. **Thickness of beds between the two coal horizons.**

For several miles below the north-easterly bend of the river, this coal seam is seen to crop out, at intervals, along the bank; in one outcrop, that represented opposite page 13 E, the following section was measured:—

	FEET.	INCHES.
Light-grey, somewhat sandy, clay shale	6	0
Brown, somewhat carbonaceous, shale	1	6
Coal	10	0
Dark clay shale	1	2
Coal	10	6
Shale	0	8
Coal	4	6
Black carbonaceous sandy shale (to water's edge)	4	6
	38	10

Analyses of coal.

Specimens from this seam were collected by Dr. Selwyn in 1873, and by Dr. Ells in 1875, and analysed by Mr. Hoffmann, with the following results:—*

"Structure, coarse lamellar; made up of alternate layers of more or less dense, bright and dull coal, and numerous interstratified layers of mineral charcoal; the surface of the denser layers parallel to the plane of deposition presents a ligneous structure; color black; lustre along the surface of bedding dull, that of the cross fracture sub-resinous to resinous; fracture uneven, that of the brighter layers, somewhat conchoidal; the brighter portions do not soil the fingers; powder almost black; it communicates a deep brownish-red colour to a boiling solution of caustic potash; by exposure to the air, becomes fissured, preferably along the line of bedding, and falls to pieces.

"Specific gravity 1·4341—Weight of one solid cubic foot 89.63 pounds.

"Analyses by slow and fast coking gave:

	Slow Coking.	*Fast Coking.*
Hygroscopic water	14·78	14·78
Volatile combustible matter	28·46	30·48
Fixed carbon	50·69	48·67
Ash	6·07	6·07
	100·00	100·00
Coke, per cent	56 76	54·74
Ratio of volatile combustible matter to fixed carbon	1:1·78	1:1·59

"Calorific power—determined by experiment:

Indicated power of fuel in calories .... 52·89
Indicated evaporative power .... 9·84 pounds of water (at 100° C.) per pound of fuel.

* Geol. Survey Report for 1882-84, p. 13

"It yields, both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellowish, slightly luminous, almost smokeless flame. The ash has a pale brownish color,—exposed to a bright red heat, it becomes very slightly agglutinated, at a most intense red heat, it becomes slightly fritted."

For four miles below this last mentioned outcrop, the banks show nothing but slight exposures of light-grey sandstone and sandy shale, and then the same coal seam rises in a low anticlinal (figured and described by Dr. Selwyn in 1873,*) and shows essentially the same section as that given above.

It has long been known that this is about the highest point on the river, where gold can be washed out of the gravel and sand bars in paying quantities, and prospectors on that account have been led to examine the banks in this vicinity very closely. In sections 35 and 36, township 50, range 4, west of the fifth principal meridian, the coal seam has been burnt out over a considerable area, and the ground is now scattered over in many places with large masses of a slag-like rock, and where these have not been covered with the alluvial deposits, beds of ashes and burnt clay and sandstone skirt the edge of the bank of undisturbed coal-bearing strata. A number of specimens of this burnt material were collected and have been assayed in the laboratory with the following interesting results: Occurrence of gold.

Two masses of slag-like rock lying at the foot of the slope in which the coal seam is exposed, taken from places one mile apart.
Trace of gold.

Arenaceous clay-shale underlying coal seam.
Trace of gold.

Ashes from burnt coal seam.
Trace of gold.

A trace of gold was also found in the parting of clay-shale in the coal seam where it had been unaffected by fire. A sample of the overlying boulder-clay was also assayed, but no gold could be detected in it.

On the west side of the river, a mile and a-half below the low anticlinal outcrop of coal above-mentioned, the seam has been burnt out and is seen to be underlain by fifty feet of whitish clay and clayey sandstone, quite different in appearance from any of the light-grey argillaceous sandstone which we have yet met with in this river, and precisely similar to the whitish clays and sands seen on the Red Deer from the mouth of Tail Creek to the mouth of Rosebud Creek, forming the upper beds of the Edmonton series.

The coal seam is here overlain by fifteen feet or more of grey sandy

* Geol. Survey Report for 1873-74, p. 49.

Top beds of Edmonton series.

shales with beds of yellow sandstone, in which are found remains of leaves of *Populus arctica*, *Populus Richardsoni ?*, *Taxodium occidentale*, *Sequoia Langsdorffii ?* and *Onoclea sensibilis*.

The beds of white clay and sand now rise gradually to the top of the banks on either side, bringing with them numerous seams of coal, varying from a few inches to several feet in thickness, as well as a few bands of nodular ironstone. A fairly typical section may be seen just below the mouth of White Lake Creek, viz:—

Section.

	FEET.	INCHES.
Superficial deposit of stratified sand...............	12	0
Coal in uneven bed, partly or largely eroded at its thickest part..................................	6	0
Almost black, somewhat shaly, unctuous clay.....	0	3
White " " " "	0	2½
Brown, rather sandy, clay..............................	0	2½
Light-grey, rather sandy, clay-shale.....................	4	0
Soft, coarse-grained, light-grey sandstone with some bands of nodular ironstone......................	7	0
Light grey, sandy shale..................................	4	0
Impure *coal*..	0	8
Light-grey sandy clay-shale, and soft clayey sandstone..	16	0
Soft dark-coloured clay-shale........................	0	8
Black fine-grained sandy shale containing a considerable quantity of *coal*.......................	0	6
Coal...	0	6
Similar black sandy shale............................	1	4
Light-grey sandstone and shale........................	18	0
	71	4

Whitefish Lake Creek.

Whitefish Lake Creek is a swift stream of clear brownish water, flowing southward out of Whitefish Lake which lies about ten miles north of the river. The channel is twenty feet wide and ten feet deep, with a bottom of gravel or sand. In September, the stream was fifteen feet wide and one foot deep. One mile and a half below the mouth of Whitefish Lake Creek, another stream five feet wide and eighteen inches deep, flows in from the north out of a wide, sloping valley, draining a lake which lies a short distance to the north. It was on the beautiful flat at the mouth of this creek that the Hudson's Bay Company had one of their old trading posts, which they called White Mud Fort, the ruins of the chimneys of which can still be seen standing like conical mounds in the midst of the long grass. From the mouth of this creek, known as White Mud Creek, the river turns abruptly and runs to the south for four miles, the banks being high on the east side, but on the west side there is a wide

J. B. TYRRELL, PHOTO., SEPT., 1886. IVES-PROCESS; G. E. DESBARATS & SON, MONTREAL.

BANK OF NORTH SASKATCHEWAN RIVER, 40 MILES ABOVE EDMONTON, ALBERTA;
SHOWING BEDS OF THE EDMONTON SUBDIVISION OF THE LARAMIÉ.

thickly-wooded flat for two miles, and then on that side, also, the bank is abrupt and high. Here the river valley becomes deep and narrow, and is bounded on both sides by banks of whitish sandstone and clay of the Edmonton series, coal seams showing themselves here and there in dark lines in the light-coloured clays and muds. After flowing four miles in a southerly direction, the river turns sharply, and runs in a general easterly direction for twenty-six miles, the valley retaining its gorge-like character, with banks 150 to 200 feet high, and with narrow flats densely wooded with large spruce. The banks however, are very much obscured by slides, so that good sections are rare, and it is very difficult to follow any beds or seams for any considerable distance. The plate on the opposite page gives a very fair idea of the general style of the scarped side of the valley, the opposite side, though steep, being generally covered with timber and underbrush. The following section may be taken as a fairly typical one, and reminds one very much of some of the sections on the Red Deer River:—

Deep narrow valley.

Section fairly typical of Edmonton series.

	FEET.	INCHES.
Boulder-clay, at the top		
Light-grey sandy clay-shale and clayey sandstone	30	0
Grey sandy shale	4	0
White plastic clay	0	8
Dark clay-shale	1	4
Coal	2	0
Plastic clay	0	7½
Coal	2	2
Dark coarse clay-shale	5	6
Coal	1	1
Dark coaly shale	1	2
Soft, black, plastic clay	2	0
Dark, friable, irregularly-fractured clay-shale, burning to a fine red terra-cotta-like mass	3	2
White and dark plastic clay	0	5
Stony *coal*	0	4
Rather dark grey fine clay-shale	1	0
Stony *coal*	0	9
White plastic clay	0	9
Coal	2	10
Light grey, sandy clay-shale, and clayey sandstone, with thin seam of impure coal, 6 feet from the bottom	35	0
	94	9½

The clay and sandstone banks when not otherwise wooded, are sometimes dotted with small sage-bush. It is in this stretch, a short distance west of the fifth principal meridian, that the old location of

the Canadian Pacific Railway crosses the Saskatchewan at an elevation of 2,200 feet above the sea and one hundred and four feet above the bed of the stream.

Several small streams fall into the river here from the south, but they have already been described, as far as known, on a previous page.

At the end of this easterly stretch the river makes a horse-shoe bend to the south and then flows off in a north-easterly direction. At the bend the following section is seen:—

	FEET.	INCHES.
Bedded superficial sand	20	0
Seam of carbonaceous shale	1	0
Light-grey sandy clay-shale holding a good many irregular nodules of ironstone and some thin seams of sandstone	40	0
Coal, for the most part, rather stony	2	8
Grey unctuous clay	0	2½
Coal, somewhat shaly towards the bottom	1	3
Black thin-bedded carbonaceous shale	0	10½
Coal	2	0
Grey clay-shale and clayey sandstone	120	0
Coal	2	8
Soft light-brown clay-shale	16	0
	206	8

The beds, for the last thirty miles down the river, seem to be lying perfectly horizontal, for though there appears to be a dip of a few feet to the mile up the river, it is probably no greater than the fall of the river in the same distance.

At the horse-shoe bend the river turns sharply in a direction N. 40° E. and continues in that direction for sixty miles in a straight line, or seventy-five miles following the course of the river.

Big Island coal seam. At the head of Big Island, five miles below this bend, a seam of coal three feet eight inches thick, crops out eighteen feet above the water, overlain by sixteen inches of hard whitish sandy clay; it is, doubtless, the same seam as that seen at the edge of the water near the bend, and sixteen feet above it in the last preceding section. A proximate analysis of a specimen from this seam gave Mr. Hoffmann:—

Hygroscopic water	8·92
Volatile combustible matter	28·70
Fixed carbon	37·44
Ash	24·94
	100·00

From Big Island to Edmonton, a distance of twelve miles, the river is winding, and bounded by banks of whitish sandstone and clay, two hundred feet high, though on account of the increased width of the valley, some beautiful flats extend along either side of the river The banks are everywhere concealed by slides, and often also by underbrush, so that no sections could be seen. At Edmonton, a coal-seam four feet thick crops out on the south bank of the river, forty feet above the water; a small quantity of coal was mined from it; but lately, Mr. Donald Ross has run a drift into the north bank through a mass of quartzite pebbles slidden from above. The seam consists of three feet of good workable coal, overlain by about one foot of dark clay-shale, which is again overlain by a considerable thickness of impure coal. It has not been found advisable to work this upper part of the seam, but it forms a very good roof for the drifts and rooms. The coal is being used in Edmonton at the different forges and throughout the town generally. It burns well, both in stoves and open grates, making a beautiful clear hot fire, and when stored under a roof, can be kept for a long time in a perfectly serviceable condition; some which had been lying in a shed for a year was still in lumps of fair size, and when burned, made an excellent fire. **Edmonton coal seam.**

A proximate analysis of a specimen from this seam, but from the south side of the river, gave Mr. Hoffmann:—

Hygroscopic water	11·47
Volatile combustible matter	36·12
Fixed carbon	48·57
Ash	3·84
	100 00

There is stated to be another seam about two feet thick in the bed of the river, but I was not able to see it on account of the height of the water. A soft unctuous clay has been several times mentioned as occurring along with the beds of coal. Some of this clay was collected from here by Dr. Selwyn in 1873, and analysed by Mr. Hoffman, who, in the appendix to Dr. Selwyn's report,* described it as follows:— **Soft unctuous clay.**

"Silica	36·48
Alumina	13·48
Protoxide of iron	1·80
Lime	2·03
Magnesia	·66
Water, (loss by ignition)	44·32
	98·78

* Geol. Survey Report for 1873-74, p. 64.

"Alkalies were not determined, though they probably make up the deficit. The material was not dried, but analysed in the moist condition in which it came from the bed. Its colour is pale greenish-grey; consistence that of soft dough; unctuous; when rubbed on the hand with a little water has a soapy feel, and possesses detergent properties; readily parts with its water, even at the ordinary temperature of the atmosphere. After drying at 100° C. may be reduced to an almost impalpable powder, which on being moistened with water, assumes all its original physical characters."

Rich alluvial flats.

From Edmonton to the mouth of Sturgeon Creek, a distance of twenty-eight miles, the river winds from side to side of a rather deep, wide valley, leaving fine alluvial flats alternately on either side, on many of which settlers have already located, and the small breakings here and there, yielding rich crops, give promise of the great agricultural prosperity of this country in the not far distant future. Opposite the flats, cut-banks are generally seen, showing light-grey sandy shale and whitish clayey sandstone, with many outcrops of small seams of coal, reminding one very much of the beds in the lower part of Rosebud Creek, of which, in fact, they are the northerly continuation, except that here there is not quite so much variety in colour, and, owing to the greater rainfall, the banks are rather more sloping, trees and shrubs are growing wherever they are able to take root, and there are no "bad lands."

Pre-glacial gravels and sands.

Above the sandstones and clays of the Laramie, we have in this section of the valley some good exposures of pre-glacial river gravels and sands: one exposure, just at the eastern end of the town site of Edmonton, showing eight feet of quartzite shingle, overlain by twelve feet of yellowish sand, into which the shingle runs up in irregular tongues in many places, showing the whole to be essentially one deposit. This is overlain by a massive sandy clay, mostly dark-coloured, containing numerous pebbles and boulders, to a thickness, as seen in some places, of twenty-five feet, and breaking along numerous joints with almost perpendicular faces. The height of the bottom of this boulder-clay varies very much with the irregularities of the surface of the underlying rock; on the higher banks it is often more than a hundred feet above the river level, and lies immediately on the Laramie, while in the valley it sometimes comes within a few feet of the level of the water, and is invariably underlain by sand and quartzite gravel.

Boulder clay.

No general dip in underlying rocks.

No general dip can be detected in the Laramie rocks on this part of the river, though they sometimes appear to incline a few feet in the mile in one direction and sometimes in another.

Sturgeon Creek has its source in, or rather above, Lake St. Ann, thirty-six miles N. 75° W. from Edmonton, and flows a little south of east till it reaches Big Lake. Leaving Big Lake, which has an area of about six square miles, it runs for twenty-one miles towards the north-east, parallel to the Saskatchewan and at a distance of from ten to twelve north-west from it; the creek then turns sharply at a right angle and flows south-east to its mouth. At the point where the trail crosses it, it is twenty feet wide and one foot deep, with a rapid current, in a valley half a mile wide and one hundred and fifty feet deep. Sturgeon Creek

The banks of the North Saskatchewan are here sloping and grassy or lightly wooded. To the mouth of Beaver Creek, a distance of thirteen miles, they preserve very much this same character, a few escarpments being seen, which, however, were found to be composed almost entirely of drift deposits, usually sand and pebbles overlain by boulder-clay. Midway between the two creeks, two feet of dark-grey clay-shale crop out at the water's edge, associated with nodules of light-brown ironstone and large lenticular masses of ferruginous sandstone, with a dip S. 45° W. of eighty feet to the mile. This bed is precisely similar to that seen on Beaver Creek, at the crossing of the Victoria and Edmonton trail, and may represent the top of the Pierre shales brought up by the continuation of the low anticlinal which, further to the south, brings the beds of the Belly River series to the surface, but, as no traces of fossils could be found, it was impossible to decide this point, and it has not been considered advisable, at present, to indicate it with the Pierre colour on the map. Low exposure of dark-gray clay shale.

A mile further down, dark shale is seen on the north bank of the river, overlain by fifty feet of light-grey sandy shale and whitish clayey sandstone holding nodules of ironstone and bands of ferruginous sandstone. Then to the mouth of Beaver Creek and for five miles below it, a distance of ten miles, the banks are sloping and generally well wooded with poplar, mixed with some spruce, with here and there cut-banks of sand often overlain by boulder-clay. On Beaver Creek itself, near its mouth, steep scarped banks of yellow sand interbedded with blue shaly clay, both containing pebbles of gneiss, quartzite, ironstone, etc., rise abruptly from the edge of the water for seventy feet. If the dip of eighty feet to the mile obtained above continues for these ten miles where the underlying rocks are covered with drift, the distance would be quite sufficient to allow the Pierre shales to cross the river, as it is not at all probable that they would have a thickness of more than six to eight hundred feet, but this is a point which for its determination will require further research in the small lateral gulleys, or perhaps even by boring. Banks composed of superficial deposits.

Five miles below the mouth of Beaver Creek, where the river turns slightly towards the north, grey clay-shale and whitish clayey sandstone are again seen. These contain nodules of sandy ironstone and bands of yellow ferruginous sandstone, the whole exposure presenting a scarped face twenty feet high. Its height gradually increases down the river, till, opposite the mouth of Sucker Creek, it is one hundred and fifty feet high, and is entirely composed of light-grey and whitish clayey sandstone and grey clay and sandy shale containing, especially towards the top, numerous flint-like nodules of ironstone, as well as irregular bands of yellow ferruginous sandstone. The otherwise naked face of the cliff is covered here and there with a few sage-bushes. This rise gives a dip to the beds, in a southerly direction, of thirty feet to the mile, and supposing the true direction of dip to be south-westward, which has been found to be the general direction of the dip throughout the western portion of this district, the beds would have a dip in that direction of about forty-five feet to the mile. The dip, fourteen miles further up the river, was seen to be eighty feet per mile, and, taking the mean of these two instances, we would have a general dip of sixty-two and a half feet to the mile and a thickness of eight hundred and seventy feet for the strata exposed in that direction.

General dip of beds.

From the mouth of Sucker Creek, the river flows 30° east of north for two miles, the banks being composed of light-coloured clayey sandstone and sandy shale; it then makes a sharp bend to 25° south of east, and sixteen miles lower down it gradually turns to the east and then to the north of east, till the mouth of White Earth River is reached. For eighteen miles of this distance, as far east as Victoria, the country to the north is open or but lightly wooded, stretching back in a beautiful plain from the sloping bank of the river; the south bank is high and thickly wooded, but showing, in many places, exposures of the whitish clayey sandstone, at heights varying from the water's edge to one hundred feet above it. Thin seams of coal also crop out at several places, though none were seen which would be of any service except for local supply.

Attractive country.

Section on Egg Creek.

The following section is well seen in the deep, narrow valley of Egg creek, about a mile south of where it flows into the North Saskatchewan opposite Victoria:—

	FEET.	INCHES.
Grey, somewhat sandy, clay-shale, coaly towards the top	4	3
Nodular ironstone	0	2
Soft light-grey sandstone	1	3
Brownish-grey shale with thin streaks of coal and nodules of ironstone	1	6

	Feet.	Inches.
Dark coaly shale	0	6
Light-grey sandy shale	1	10
Soft grey sandstone	1	3
Impure *lignite*	0	6
Drab-coloured sandy clay-shale	2	3
Bluish-grey soft sandstone, in places harder and false-bedded	9	0
Reddish-grey clay, but mostly covered	1	6
Fine grey clay-shale	1	0
Thinly-laminated coaly shale	1	0
Light-grey clay-shale	2	0
Sandy shale	0	6
Light-grey clay-shale	3	6
Light-grey soft sandy shale and sandstone	6	0
Light-grey sandy clay-shale	3	0
Grey, partly carbonaceous, clay-shale	1	6
Grey clay-shale, dark at the top but becoming quite light at the bottom	5	9
Light-grey fine clay-shale with some thin bands of blueish-grey, soft sandstone	15	0
Coal	1	3
Carbonaceous shale	0	10
Light-grey sandy shale	7	0
Light-grey clay-shale with bands of ironstone	6	0
Coal	1	1
Covered (probably mostly light-grey shale)	20	0
	99	5

Some specimens of coal collected from the lowest of these seams, were analyzed by Mr. Hoffmann and found to contain:— **Coal on Egg Creek.**

Hygroscopic water	11·91
Volatile combustible matter	36·39
Fixed carbon	45·04
Ash	6·66
	100·00

From the mouth of Egg Creek, for about four miles down the river, no rocks are seen in place, and then the whitish clayey sandstones have disappeared, and instead we have low exposures of light-grey and yellow soft sandstone containing large lenticular concretionary nodules of hard grey yellow-weathering sandstone, usually false-bedded and often holding, close to their lower surface, nodules of flinty ironstone and fragments of silicified wood. **Soft yellow sandstone.**

From the outcrop of the Big Coal Seam, opposite Goose Encampment, to the mouth of Egg creek or a little east of that point, we have con-

Extent of Edmonton series on the North Saskatchewan.

sidered the beds as all belonging to our lower division of the Laramie, namely, to the Edmonton series. As far east as the mouth of Sturgeon Creek, there can be no doubt that this is the true position of the rocks seen, as they can be traced in, practically, an unbroken section, for the whole distance. East of Sturgeon Creek, the geology, as made out on this one section down the river, is not so clear, as the rocks are not constant in their character, and when seen, have an appreciable dip which might carry a formation only a few hundred feet in thickness, across the section without a trace of it being seen. In the entire absence of palæontological evidence of the age of the beds, though fossils were carefully searched for wherever any exposures of the underlying rocks were seen, and considering the undisturbed condition of the rocks throughout the whole district, we feel justified in assuming that the light dip towards the south-west in this portion of the country, is constant, and that every mile in a north-easterly direction takes us into lower beds. It is not at all improbable, that the discovery of fossils may at any time show that the line of the bottom of the Edmonton series has been drawn too low, but at present we have nothing to guide us but the change in the character of the rocks, as seen above, from soft light-coloured argillaceous sandstone and shale, to purer sandstone, a change observed in numerous places further south, where we pass from the lowest beds of the Laramie to the sandstone of the Fox Hill group. It is possible, too, that the soft white sandstones which crop out around the northwesterly angle of the North Saskatchewan, may belong to the underlying Belly River series, but as they are, certainly, the same beds which extend as far west as Victoria, there is nothing to indicate a dip to the north-east sufficiently steep to carry down again, not only the exposed beds of the Belly River series, but also all the lower beds of the Pierre, for we will see shortly that the yellow sandstones, outcropping four miles to the east of Victoria and for a considerable distance further down the river, are underlain by dark-clay shales, of the Pierre group.

Uncertain age of some of the beds.

From a point four miles below Victoria to the mouth of the White Earth River, a distance of four miles, grey and yellowish sandstones are exposed at intervals along the south bank in cut-banks thirty feet high. Just below the mouth of White Earth River, the North Saskatchewan turns sharply to the north, and the banks become more sloping, being covered with small poplar mixed with some spruce. Concretionary sandstone is, however, seen in several places close to the river, underlain by dark friable clay-shale, as seen in the following section:—

Concretionary sandstone.

	FEET.
Stratified sandy clay...........................	5
Light-yellow sandstone with large sandstone concretions..	8
Dark-grey clay-shale, in some places sandy or including beds of sand; it holds a few large lenticular nodules of calcareous ironstone...............	30

Five miles below White Earth River, the North Saskatchewan turns more to the east, and flows on a bearing S. 30° E. for twelve miles, the banks are composed of horizontal beds of grey sandy shale, and grey and yellow concretionary sandstone, and become gradually higher down the stream.

The river now turns due east to the mouth of Saddle Creek, high hills skirting it on either side. The sandstones gradually disappear, rising up over the tops of the banks; and low outcrops of somewhat sandy shale, close to the edge of the river, are all that is seen of the underlying rocks. On Saddle Creek, a short distance from its mouth, yellowish-grey shale is seen for 120 feet above the water, overlain by a band of soft sandstone, above which there are no exposures, though the banks are sandy. The valley is here 350 feet deep and very wide, with rough uneven slopes on either side, presenting steep hills and ridges caused by slides of the overlying clay. They are here thickly covered with berry bushes, though in the more rainless areas further south the same cause gives rise to perfectly bare bad-land banks. Sandy shale.

Five miles above the mouth of Saddle Lake Creek, at the old crossing of the Lac La Biche trail, the valley is thus spoken of by Dr. Hector, who visited it in 1858:—"The country bordering the river in this part of its course is very beautiful, as the high banks retire and form, by combining with a still higher table land, undulating hills that rise to a height of 300 to 400 feet. On the north side are thus formed the Snake Hills, which are free from wood except in the ravines."* Crossing of Lac La Biche trail.

From the mouth of Saddle Lake Creek, which is a small stream twelve feet wide and one foot deep, the river flows to the south, in a wide sloping valley, in the sides of which the rocks are almost entirely hidden by slides of superficial deposits or by the thick growth of herbage and underbrush. In two or three places, however, close to the edge of the water, grey clay-shale crops out, holding nodules and concretions of ironstone and ferruginous sandstone. At the end of this southerly stretch, the river turns sharply to the east passing the old Roman Catholic Mission of St. Paul, now deserted. The valley here is bounded by beautiful terraced banks rising at a distance of about a mile on either side to a height of two hundred feet. The Old mission of St. Paul.

* Journals, etc., relative to the Exploration by Capt. Palliser, p. 80.

north bank presents a beautiful strip of open prairie, while to the south, the terraces are covered with willow and berry bushes. Low exposures of dark clay-shale with ironstone nodules are also seen along this stretch. The character of the valley from old St. Paul down to Fort Pitt, is very constant, sloping banks rising on either side into higher or lower hills, often by a series of terraces, the south bank being generally much more thickly wooded than the north. There are very few rock exposures, and those consist of clay-shale with septarian nodules, till we approach the mouth of Moose Hill Creek, opposite Island No. 14, where a scarped bank is seen one hundred feet high of. dark slate-grey clay-shale with lenticular nodules of calcareous ironstone, in which have been been found some fragments

Pierre fossils. of the following typically Pierre fossils, viz.: *Baculites ovatus*, *B. com, pressus*, *Scaphites nodosus*, *Pholadomya subventricosa*, and a species of *Inoceramus*. Between the mouth of Moose Hill Creek and Vermilion River, the banks are still sloping and occasionally show small exposures of similar dark clay-shale containing a few scattered remains of *Baculites.* At the mouth of the Vermilion, an excellent section one hundred feet high, is exposed of the dark clay-shales of the Pierre group, holding, towards the top, numerous crystals of selenite, as well as a band of calcareous ironstone, and a thin band of yellow soapy clay. In the ironstone were found the fossils mentioned on page 100 E. Between the mouth of the Vermilion River and Fort Pitt, which is situated nine miles beyond the easterly limit of the accompanying map, a few low exposures of dark clay-shale were seen close to the edge of the water, and in several places on the bank the rock had slidden down and exposed fine sections of dark clay-shale, from some of which he following fossils were collected: *Baculites ovatus*, *B. compressus*, *Inoceramus Sagensis*, *I. Vanuxemi*, *Pholadomya subventricosa*, *Thetis ?* sp. and *Martesia tumidifrons*.

FOOT-HILLS.

Foot Hills. Shown in the south-west angle of the accompanying map, and occupying an area of eleven hundred square miles, is a district which has originally been forest-clad, but the greater part of the finer timber has of late years been burnt, and is now scattered over the ground in extensive stretches of wind-fall. The country is essentially a succession of long sandstone ridges separated by narrow valleys, the bottoms of which are usually impassable morasses; in some places, these are firm enough to support a growth of small spruce and tamarac, while often they are very soft and covered with moss or rank tufted grass. On account of the almost inaccessible character of this district

it has been impossible for me to examine it in any detail in the short time which has been devoted to the whole region embraced in this report, and the remarks made here apply more especially to the outer and eastern portion of the hills.

The foot-hills are generally marked off from the Rocky Mountains proper by the line of outcrop of a great fault which runs roughly in a north-north-westerly direction, and brings the Palæozoic limestones into contact with the softer Cretaceous and Laramie shales and sandstones, the limestones rising in an abrupt mural escarpment from two to three thousand feet above the top of the highest of the foot-hills.

The line of the eastern edge of the Palæozoic rocks is drawn on the map from a sketch kindly furnished me by Mr. McConnell of this Survey, whose report forms Part D. of the Annual Report, 1886.

The streams which drain these hills, enumerated in order from south to north, are the Bow, Ghost, Little Red Deer, Fallen Timber, Red Deer, James and Clearwater rivers, all of them streams of clear blue water from the mountains. **Streams draining the Foot Hills.**

On the Bow River, a short distance east of the mouth of Coal Creek, the sandstones of the Laramie begin to show a decided dip eastward, and close to the mouth of the creek, sandstone and shale crop out with a dip N. 70° E. of 30°, bringing to the surface a seam of bituminous coal. The following section was obtained on the creek, a short distance from the river, at a place where a few years ago a small quantity of coal was taken out for local use:— **Bow River coal seam.**

	FEET.	INCHES.
Compact grey sandstone	30	0
Shale and ferruginous sandstone	4	0
Coal, with a thin parting of clay running through the middle	2	10
Shale	15	0
Hard grey sandstone	5	0
	56	10

The coal is generally lamellar, though towards the bottom of the seam it breaks off in lumps of moderate size.

Following the strike of the beds, the "Bow River Mining Company" sank a shaft on the south side of Bow River and succeeded in striking the coal a few feet below the surface. The following section obtained at this point was kindly furnished to Dr. G. M. Dawson by Mr. J. W. Vaughan:—

	FEET.	INCHES.
Rock	..	..
Coal	1	0
Black shale	2	9
Coal	1	6
Clay	0	4
Coal	2	6
Clay	0	2
Coal	2	7
Warrant	..	..
	10	10

Analysis of coal.

Specimens from both of the above localities were analysed by Mr. Hoffmann, of the survey, with the following results:—

From north of the Bow River: *

	Slow Coking.	*Fast Coking.*
Hygroscopic water	4·93	4·93
Volatile combustible matter	27·22	33·55
Fixed carbon	52·54	46·21
Ash	15·31	15·31
	100·00	100·00

From the mine to the south of Bow River:

	Fast Coking.
Hygroscopic water	4·41
Volatile combustible matter	40·32
Fixed carbon	48·27
Ash	7·00
	100·00

The coke is firm and compact.

From the two sections given above, it will be seen that the seam is very variable in thickness, as it changes from two feet ten inches to seven feet seven inches in the short distance of three-quarters of a mile. The coal, however, is of excellent quality, and this seam will, doubtless, be an important source of supply throughout all the parts of the North-West Territory and Manitoba, to which it can be carried by rail.

Laramie age of seam.

This seam is of undoubted Laramie age, but, whether as low as the beds of the Edmonton series, it is difficult to say in the absence of all palæontological evidence, and especially as the rocks of this series along their western outcrop have lost all, or almost all, the main peculiarities which on the plains serve to mark them off sharply from the beds both above and below them.

* Geol. Survey Report for 1882-84, p. 32 M.

Half a mile west of the mouth of Coal Creek, a sharp anticlinal crosses the river, and from that point westward, sandstones and dark clay-shales are met with, usually inclined at a high angle and folded backwards and forwards on each other in a very intricate manner. In these folded rocks the few fossils that have been collected give evidence of the presence of the Laramie, the Pierre, and the Benton, while at Canmore and further south, plant remains were collected by Dr. G. M. Dawson, which proved the presence of rocks still lower down in the Cretaceous. Rocks intricately folded.

On the west side of the valley of Spencer Creek, a mile above the crossing of the Calgary-Morley trail, dark-grey clay-shales are seen dipping westerly, and including, along with bands of sandstone and ironstone, a twenty-inch seam of finely powdered coal, and four feet above the coal, there is a band of shale rather harder than the rest, holding numerous imperfect impressions of leaves. Then, passing westward, over a ridge of sandstone, which is also dipping westerly at a high angle, we reach the dark shales again in the valley of Ghost River. Up this stream, the shales gradually change to sandy shales and sandstones, and at a distance of two miles from Bow River, a sharp, synclinal crosses the valley with a strike N. 19° W., the beds suddenly changing from a high dip, S. 71° W., to a dip of about 30°, N. 71° E. A third of a mile further up the stream, at a point where a small brook flowing in a deep, narrow valley, joins the river from the south-west, the last-mentioned sandstones and sandy shales, which are of a grey or slightly olive colour, are underlain by dark clay-shales holding thin bands of ironstone nodules as well as beds of hard sandy argillite mixed with iron pyrites and some fragments of marine cretaceous fossils, such as *Inoceramus*, *Modiola ?*, etc. It would appear highly probable that these shales belong to the horizon of the Pierre, while the sandstones and sandy shales which overlie them are of the age of the bottom of the Laramie. For the next three miles and a half, the banks of the river are composed of vertical or highly inclined beds of olive or dark sandy or clay-shale, intercalated with beds of sandstone, the shales in the western part being more slaty than the others and containing well-preserved examples of *Baculites compressus*, which is a form highly characteristic of the Fox Hill and Pierre beds. This belt, therefore, doubtless is an area of much folded rocks of the groups above named, the harder overlying Laramie having been shoved upwards by the compressions, and afterwards denuded away, or left as high rocky ridges lying on the top of upturned edges of the shales. Finally, at the mouth of the north fork of Ghost River, the beds have again assumed more the character Spencer Creek. Rocks on Ghost River. Bands of Pierre shales.

of sandstones with a high westerly dip, and immediately to the north, there is a high sandstone ridge, the harder beds of which project as naked rocky ledges through the generally grassy hill-side, each ledge, however, being bordered by a long row of scrub pines.

Little Red Deer River.

Following the outer edge of the foot-hills northward, or rather, in the general direction of the strike of the beds, we reach the Little Red Deer River, where it breaks through the most easterly ridge in a rocky defile, the sides of which, where trees can grow, are thickly covered with spruce. This ridge represents the top of the outer anticlinal of the disturbed belt, and from it the beds dip both to the east and to the west. It consists of vertical beds of grey sandy shale and sandstone of Laramie age, the fold not having been great enough to bring the lower formations to the surface. Ascending the stream to the mouth of Grease Creek, a distance of three miles and a half by the valley, these sandstones and sandy shales are seen dipping westerly with a constantly decreasing angle, till at the latter place they are apparently quite horizontal, the whole thickness of the beds here brought to the surface being considerably over 5,000 feet. It might be here noticed that Dr. Dawson, in his report on the region immediately to the south, gives the Laramie a minimum thickness of 5,750 feet.

Laramie anticlinal.

Thickness of beds.

Wide synclinal.

West of the mouth of Grease Creek a high ridge runs N. 20° W. and S. 20° E., occupying the centre of a wide synclinal, and west of it the rocks, which consist of thick-bedded light-grey sandstones and light-greenish sandy shales, assume an easterly dip which becomes gradually steeper as the valley is ascended, till at a distance of two and a half miles above Grease Creek, and after another ridge of highly inclined sandstone is passed through, dark clay-shale holding lenticular nodules of ironstone is met with opposite a low longitudinal valley. For three-quarters of a mile up the river these dark-grey clay-shales crop out, interbedded with greyish sandstone, dipping N. 70° E. at an angle of 75°; they represent the irregularly folded beds of the Fox Hill and Pierre groups.

The following section represents the arrangement of the rocks on this river as far west as they have been worked out.:—

SECTION ON LITTLE RED DEER RIVER IN "FOOT-HILLS."

Horizontal scale 2 miles to 1 inch

Fallen Timber Creek.

Towards the north, the next transverse valley reached is that of Fallen Timber Creek which, in its outer part is, however, wide and

swampy, and only in one place about the centre of range 6, was any exposure of the underlying rocks seen. They are here rather hard grey sandstones, forming a sharp anticlinal with a strike N. 20 W., doubtless a continuation of the outer anticlinal on Little Red Deer River. The flats on either side of the stream are underlain by a quartzite rubble which has been washed down from the Palæozoic rocks of the mountains and scattered over the bed of the constantly changing channel, the finer sand and gravel being washed out towards the plains. North of this creek the foot-hills are not so regular as to the south of it, and there are no continuous ridges east of the Stoney trail, as they have been irregularly denuded away and the country is left composed of detached and rounded hills.

The next river in order as we go north is the Red Deer, which is the largest stream flowing from the mountains between the Bow and the North Saskatchewan. **Red Deer River**

At the crossing of the Stoney trail, much-folded beds of sandstone and sandy shale are exposed in the low banks of the channel, and along the valley, sandstone ridges run off N. 20° W., separated by low valleys representing doubtless shaly belts. The sandstone dips S. 70° W. < 60-70°. Two miles and a half below the bend, at the mouth of William's Creek, the rocks are still dipping in the same direction, but at the low angle of 15-20°. Again, a little above where the river runs out on Bearberry Prairie, sandstones and greenish sandy shales are seen in the hill back from the river, folded on each other several times, while in the bank of the channel similar sandstones and shales are seen in a vertical position, enclosing in some places, a thin bed of coal. About a mile and a quarter above the eastern side of the outer hill, the rocks consist of greenish-grey, rather hard sandstones and green or olive sandy shales, very much folded and broken, and half a mile further up still, similar rocks are met with, dipping N. 60° E. < 80° and enclosing a seam of coal, probably about nine feet thick, but so folded and slicken-sided, that it was impossible to measure it with any degree of accuracy. Specimens from this seam were analysed by Mr. Hoffmann, with the following result:— **High dip.** **Coal seam.**

Hygroscopic water	4·97
Volatile combustible matter	36·87
Fixed carbon	54·05
Ash	4·11
	100·00

Coke non-coherent.

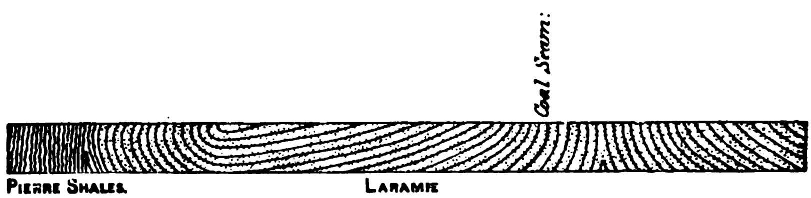
A bed of sandstone a few feet below the coal was found to contain, besides a cone of *Sequoia Nordenskioldii*, impressions of leaves of *Platanus* **Fossil leaves.**

nobilis and *Populus acerifolia,* all of which are plants characteristic of the upper division of the Laramie, and hence it is not improbable that this coal seam may be on the same horizon as the seam which crops out near Rocky Mountain House on the Saskatchewan. In a bed of sandstone a few yards from this place, a smoothly-rounded quartzite pebble an inch and a half in greatest diameter, was found, an interesting discovery, as it is one among a number of circumstances mentioned further on, which indicate proximity to the ancient coast line of the great Laramie lake or inland sea. East of this ridge the rocks gradually slope off to the plains so that we have here again the outer anticlinal of the foot-hills, probably a contination northward of the same anticlinal which we saw on Little Red Deer and Fallen Timber Rivers, though in that case, its general strike is four to five degrees further west than was determined at any observed exposure, and, as on these two latter streams, there is here no indication that rocks older than the Laramie are brought to the surface.

Included pebble.

The following section will serve to give a general idea of the rocks as seen on the part of the river just described :—

SECTION ON RED DEER RIVER IN "FOOT-HILLS."



Horizontal scale 2 miles to 1 inch

North of the Red Deer, only a small area of foot-hills comes within the limit of the district comprised on the map, and it is, as yet, unexplored. Coal is reported to occur on James River, the North Saskatchewan, and the Brazeau, and when it is deemed advisable to have this disturbed country thoroughly examined, the results will, no doubt, well repay the trouble and expense incurred.

SYSTEMATIC GEOLOGY.

Under the head of Descriptive Geology, we have considered the rocks occurring in this district, as they were met with, in journeying through the country, either in the sides of the numerous valleys or in higher or lower escarpments rising above the general level of the plains. Under the present title, it is our purpose to present a short *résumé* of the character and distribution of the different series of strata, beginning with the oldest, and continuing upward to those most recently deposited. **Table of deposits.**

The following table, arranged in descending order, will serve to show the general character of the different groups or formations:—

	FEET.
POST-TERTIARY.	
Recent deposits.—Sands, clays and silts	...
Upper Boulder-clay.—Light-grey sand, and generally, indistinctly stratified clay, containing numerous pebbles of gneiss, quartzite, etc.	...
Lower Boulder-clay.—Dark-grey, thick-bedded, or massive, sandy clays containing pebbles of quartzite, etc., and numerous fragments of lignite	...
Pebble bed.—Quartzite shingle lying in a loose sandy matrix	...
MIOCENE.	
Gravels, fine sands and argillaceous marls, the gravels consisting of quartzite shingle, being sometimes cemented into a hard conglomerate by calcareous cement	270
LARAMIE.	
Paskapoo Series.—Grey and brownish-weathering, lamellar or massive sandstones, and olive sandy shales. This is an exclusively fresh-water deposit	5,700
Edmonton Series.—Soft whitish sandstones and white or grey, often arenaceous, clays, with bands and nodules of clay ironstone and numerous seams of lignite. These are of brackish water origin and correspond to the lowest portion of the St. Mary River series of Dr. Dawson's Report (Geol. Survey Report for 1882-84, p. 114 C.)	700
FOX HILL and PIERRE.	
Brownish-weathering sandstones and dark-grey clay-shales	600
BELLY RIVER SERIES.	
Soft, whitish sandstones and arenaceous clays, changing towards the east to light-brownish and yellowish sandstones and sandy shales, bottom not seen	...

In the foot-hills, evidence was found of the presence of rocks of the age of the Benton shales, which immediately underlie the sandstones of

No unconformity below the Laramie.

the Belly River series, but our knowledge of them is, as yet, too imperfect to allow of our treating of them, in any way, and we can therefore simply record their occurrence.

No intrusive rocks occur anywhere throughout the district, and below the top of the Laramie there is no evidence of any unconformity between the different formations, although, in some cases, the extreme irregularity of the bedding gives the strata very much the appearance of having been laid down unconformably one on the other.

Belly River Series.

Character of rocks.

This series is represented by white or light-grey clays and soft clayey sandstones, interbedded with bands and nodules of clay ironstone. These nodules are often highly calcareous, breaking with a smooth, sharp fracture. Towards the centre, on a freshly broken surface, they are of a clear slate-grey colour, around are darker and darker layers, till the outer one, which is very dark-brown, almost black.

As has already been pointed out in the reports of Dr. Dawson and Mr. McConnell, this series, if followed toward the east, is found to lose gradually its clayey character, and to consist of purer and much more massive sandstones, generally of a yellowish colour. When the beds are white and clayey, it is possible to trace with comparative ease and acuracy the line of junction between it and the overlying Pierre shales, as in river valleys it almost everwhere presents white sandy escarpments to its very summit, above which the land rises gently to the level of the surrounding country, and wherever this rise is cut through by small creeks the rock is seen to be dark-grey Pierre shales. This is especially the case along the valley of Red Deer River between long. 111° and 112° W., a short distance south of the edge of the accompanying map, and also on Battle River for several miles below the Elbow.

Character of valleys in the white beds.

Further east, however, where the beds become harder and much more sandy, the line between these two formations becomes much more difficult to trace out, as there is little or no difference between these sandstones and those with the character of the Fox Hill group, which are interbedded, almost everywhere, with the shales of the Pierre, though typical Fox Hill fossils are generally found in these in considerable abundance, while in the yellow sandstones that underlie the shales, no fossils of any kind have ever been found within this district. Even in the white beds further west, very few fragments of fossil mollusca were found, and these belonged to essentially fresh-water genera such as *Unio*, *Sphærium*, etc.

Unfossiliferous character of beds.

Remains of plants are, however, comparatively common, and generally in the form of fragments of wood presenting every grade of preservation between pieces that are seen merely as obscure markings in the coarse sandstone, and those which are perfectly silicified and shew all the structure of the original woody tissue. Fragments of leaves were also occasionally met with, from among specimens of which were identified *Trapa borealis*, Heer, *Salisburia*, sp., and *Podocarpites Tyrrellii*, Dawson. Beside these, Sir Wm. Dawson has identified the following genera of fossil woods from among specimens brought from Ribstone Creek:*—*Sequoia* of the types of *gigantea* and *sempervirens; Thuja* of the type of *occidentalis; Betula* and *Platanus*. The three former have been found in other localities in the Belly River series, while the first of the *Sequoias* and *Betula* are also known from the Pierre shales. Plant remains common.

On account of the extreme paucity of sections, it has been impossible in most cases, to determine the precise confines of this series, though enough is known to enable us to fix its general outline as it is laid down on the map. Its northern limit is the part most doubtful, and it is not at all impossible that instead of dipping under and disappearing altogether near the north-west bend of Vermilion River, it merely narrows very much here or perhaps disappears under the overlying Pierre for a short distance and reappears at the north-west angle of the North Saskatchewan, where a range of white sandstone cliffs occupies the southern bank for several miles. In this case, the Pierre shales must cross the valley of the North Saskatchewan in the vicinity of the mouth of Beaver Creek, and as there is very little evidence as yet forthcoming on that point, we have deemed it advisable to consider that the sandstones, at the above mentioned place, belong to the lower part of the Laramie series. Boundaries of the formation.

No workable coal seams have been found in this series, though a thin seam crops out near a small lake in Buffalo Coulée. No coal.

Fox Hill and Pierre Group.

This group consists of dark or light-grey, very friable clay shales, weathering down into a soft tenaceous clay; interbedded with bands of coarse-grained yellow sandstone. Unlike the beds both above and below it is of purely marine origin, having been laid down in a sea of varying, though generally very considerable depth. Character of rocks.

The thickness of the formation, wherever it could be measured, was Low anticlinal.

* Note on Fossil Woods and other Plant Remains, from the Cretaceous and Laramie Formations of the Western Territory of Canada, by Sir William Dawson, F.R.S. Trans. Roy. Soc. Canada, 1887, Sect. IV., p. 31.

found to be from six to seven hundred feet. In the eastern portion of the district, it lies in a very low anticlinal, with a strike of N 30° W, the top of which has been denuded away, leaving the sandstones and clays of the Belly river series at the surface, while further west it disappears under the sandstones of the Laramie, and is not seen again till the foot-hills are reached, where its strata either are vertical or dip at a high angle to the west or east, being often folded backwards and forwards in a very complicated manner, the overlying beds having been squeezed out and removed by denudation.

Fox Hill and Pierre inseparable.

It is quite impossible here to separate the Fox Hill sandstone from the Pierre shales, as they are completely interbedded from the top to the bottom of the group. In descending Battle River, this is particularly noticeable, as at the top of the group, yellow sandstones are met with containing *Placenticeras placenta*, *Teredo* burrows, etc., and at the bottom a sandstone quite indistinguishable from that above is seen holding precisely the same fossils. In the southern part of the district, nodules of clay ironstone are common throughout the shale, and fossils are plentiful, both in the nodules and in thin bands of included sandstone, but to the northward, fossils become much more rare and new species begin to appear, which are not known to the south.

List of fossils.

The fossils found in the district up to the present are:—

Ostrea sp.
Pteria linguiformis, Evans and Shumard, var. *subgibbosa*, Meek.
Inoceramus Sagensis, var. *Nebrascensis*, Owen.
Inoceramus Vanuxemi, Meek and Hayden.
Gervillia recta, var. *borealis*, Whiteaves.
Modiola sp.
Lucina occidentalis, Morton.
Tancredia Americana, Meek and Hayden.
Cyprina ovata, Meek and Hayden.
Cyprina subtrapeziformis, n. sp.
Astarte sp.
Protocardia subquadrata, Evans and Shumard.
Protocardia borealis, Whiteaves.
Linearia formosa ? Meek and Hayden.
Pholadomya subventricosa, Meek and Hayden.
Periploma, sp.
Liopistha undata, Meek and Hayden.
Panopæa subovalis, n. sp.
Solecurtus (Tagelus) occidentalis, n. sp.
Martesia tumidifrons, n. sp.
Teredo or *Turnus* burrows.

Hydatina parvula, n. sp.
Anisomyon, fragment.
Lunatia concinna, Hall and Meek.
Baculites ovatus, Say.
Baculites grandis, Hall and Meek.
Baculites compressus, Say.
Scaphites nodosus, Owen.
Placenticeras placenta, Dekay, var. *intercalare*, Meek.
Palæastacus ornatus n. sp.
Pectoral of a Selachian.
Abietites Tyrrellii, Dawson.

No workable beds of coal occur in this group within the district, though in the shales on the top of the high ridge to the north of the Neutral Hills, a thin band of carbonaceous shale is seen over a considerable area, and at Egg Creek, near the North Saskatchewan, there is a thin seam of coal of fine quality. No workable beds of coal.

The rocks of this group on the plains are either perfectly level or dip a few feet to the mile in a south-westerly or north-easterly direction, but in the vicinity of the mountains, they have been very much disturbed, and we find sandstones and shales folded into each other in a very complicated manner.

The distribution of this group throughout other parts of Manitoba and the North-West, has already been worked out with considerable accuracy by other members of this Survey from long. 106° to the base of the mountains as far north as lat. 51°. It extends eastward, roughly speaking, as far as the edge of the Pembina escarpment. To the northward it is represented by the shales found by Dr. Bell on the Athabasca River, below the mouth of Biche River,* and in the Peace River region by Dr. Dawson's "Upper Shales" or "Smoky River group," which there have a thickness of three hundred and fifty feet.† Extent beyond the limits of the district.

Edmonton Series.

This is perhaps, on the whole, the most characteristic series of the entire region, for though its thickness, wherever determinable, was never found to exceed seven hundred feet, the horizontal position of the strata causes it to underlie a very large extent of country.

It consists generally of whitish or light-grey clay and soft clayey sandstone, weathering very rapidly with more or less rounded outlines. In some places, as on Red Deer River and in the Hand Character of the rock.

* Geol. Survey Report for 1882-84, p. 8 CC.
† Geol. Survey Report for 1879-80, p. 122 B. etc.

Hills, it is seamed with a great number of beds of ironstone, which with thin beds of lignite and lignitic shale, give a definite banded character to all the escarpments. It also contains a great number of nodules of compact ironstone, which are often perched on little pinacles cut out of the soft sandstone. In the northern portion especially along the North Saskatchewan, the banded appearance is seldom seen, though, with the exception of a smaller quantity of ironstone, the rock has very much the same character as further south.

Coal-bearing horizon.

This is essentially the coal-bearing horizon within the district, all the coal found east of the foot-hills, except probably the seams on the Upper North Saskatchewan and at Egg Creek, being of this age. The top of the formation is marked by an extensive coal deposit, seen first in the Wintering Hills as a thin bed of carbonaceous shale, but on being traced northward is found to thicken very greatly, till on the North Saskatchewan, near Goose Encampment, it has a thickness of twenty-five feet. The bottom of the series lies conformably on the Pierre shales, without any sharp line of demarcation between the two. In fact, the shales gradually lose their massive character, and change almost insensibly into thin beds, which are of decidedly brackish-water origin. In the Pierre, remains of land plants and animals are very rare, while here traces of land plants become fairly plentiful, and on Red Deer River, Dinosaurian bones are met with in great abundance, showing, with the presence of estuarine shells, the partly land-locked character of the area within which the beds were deposited.

List of fossils.

Besides the fragments of teeth and bones of Dinosaurs that Prof. Cope has kindly undertaken to determine, the following fossils were found in this formation within the district:—

Ostrea glabra, Meek and Hayden.
Unio Danæ, Meek and Hayden.
Corbicula occidentalis, Meek and Hayden.
Panopæa simulatrix, Whiteaves.
Panopæa curta, Whiteaves.
Trapa borealis, Heer.
Salisburia, sp.
Carpolithes, sp.
Fragments of exogenous leaves and woods of *Sequoia* of the types of *gigantea* and *sempervirens*, and a species of *Thuja*.

Extent on the North Saskatchewan.

As will be seen by reference to the map, this series underlies a considerable belt of country extending, on the North Saskatchewan, from the outcrop of the "Big Coal Seam" to or a little beyond its easterly

bend north of the Beaver Hills; and it stretches a little south of east to Red Deer River in the vicinity of the Hand Hills, comprising the lower part of the bold escarpment which there forms the south-western boundary of these hills.

To the west, this series gradually disappears under the overlying beds of the Paskapoo series, and in the foot-hills no sign of its presence could be detected, although, in many places, the junction of the Pierre and Laramie was clearly seen, the sandstones of the Paskapoo series appearing to rest conformably on the shales of the Pierre, so that the Edmonton series seems to thin out and disappear between its western outcrop and the eastern edge of the foot-hills.

Extent beyond the limits of the district.

Outside the area embraced in the present map, these beds have been already mentioned and described by Dr. Dawson* as outcropping on the Old Man, Little Bow and Bow rivers, and forming a brackish-water transition series between the overlying Laramie and the Pierre; and by Mr. McConnell in the Cypress Hills region, who calls them the lower division of the Laramie, and writes of them as follows:—†"The lower one (division), which succeeds the Fox Hill conformably wherever the contact plane of the two formations was observed, bears a strong resemblance to the upper part of the Belly River series, and consists of about 150 feet of feebly coherent greyish and pure white clays, sandy clays, and sands, with occasional beds of carbonaceous shales and lignite. A small bed of black clay was also found to be pretty widely distributed. The beds of pure white sands and clays form the most distinctive feature of this band, and were observed, with few exceptions, wherever the base of the formation was exposed. In the bad lands south of Wood Mountain this division consists almost exclusively of clay."

Now, turning northward to the Peace River region, this series is easily recognized in Dr. Dawson's Wapiti River group, which, on the lower part of the Wapiti River and on Smoky River, overlies the Pierre shales with a thickness of two hundred feet or more.‡ Dr. Dawson also recognized the Wapiti River group on the upper portion of the Athabasca River,§ though it is probable that the rocks seen above the outcrop of the ten-feet coal seam belong to the next overlying series. Beds belonging to the lower part of the Laramie, and perhaps of the age of this series, were found by Dr. Dawson in the Rocky Mountains, near the headwaters of Old Man and Highwood rivers, folded in with older Mesozoic and Palæozoic rocks.

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* Geol. Survey Report for 1882-84, p. 114 C.
† Geol. Survey Report for 1885, p. 67 C.
‡ Geol. Survey Report for 1879-80, p. 124 B.
§ Loc. cit., p. 126 B.
‖ Geol. Survey Report for 1885, pp. 89 and 92 B.

Presence of gold rocks of this formation.

The occurrence of gold in the rocks of the upper part of this series is an interesting fact brought to light by the analyses mentioned on page 109 E. It would seem from these analyses that gold is scattered in small quantities through the rocks of the Edmonton Series in the vicinity of the "Big Coal Seam" on the North Saskatchewan, and as it is found on the bars in the river in paying quantities as far east as this series of rocks extends, it is not improbable that gold may be found sparsely scattered through these sandstones and clays, or even through any of the underlying formations. The river annually washes a large quantity of these soft rocks from its banks, and separates the gold, which settles with the heavier sand and gravel on the bars running out into the stream, while the finer material is carried further east and continues to whiten the water as far as Cedar Lake.

Miners assert that the coarsest gold is found in the neighborhood of the above mentioned coal seam, and that it becomes finer as they go down the river.

Gold not derived from Rocky Mountains.

Dr. Selwyn recognized the fact that the gold in the Saskatchewan was not derived from the mountains at its source, but rather was washed out of the soft rocks which form its banks, after it leaves the harder strata of the mountains; and he considered that it was disseminated throughout the "drifts composed of granitoid gneiss, with hornblendic and micaceous schist, quartz and limestone, which are spread over the face of the country for hundreds of miles and which must have been themselves largely derived from the denudation of the great belt of Laurentian and other crystalline rocks, which extend from the shores of Lake Superior north-westerly to the Arctic Sea." (l. c., p. 58.) It is not improbable that some gold is derived from the overlying drift; but some is certainly, as above stated, derived from the underlying rocks of the Edmonton Series, especially about the horizon of this coal seam which forms their upper boundary.

The question of the source from which the gold was originally derived therefore involves that of the materials which form the sandstones and clays of this series, but the information at hand for the determination of that point is very small.

Sandstone probably derived from area of granitoid rocks.

It will be seen by reference to page 132 E that this series is considered to be of brakish water origin, and that the position of the western shore-line of the sea in which it was deposited lay but a short distance beyond the western limit of its present outcrop, while the sea itself stretched far out towards the north, the east and the south. As much of the material of which these rocks is composed is a coarse heavy sand that would not readily have been carried from one shore to another by ocean-currents, it seems more reasonable to suppose that it was derived from the wear of the adjacent coast-line, or rather, as the

coast was in all probability skirted by a wide belt of marsh, was brought down from the high lands in the interior by rapid streams that poured their waters, laden with detrital material, into this shallow sea. At present the Rocky Mountains occupy a position just west of, or in some places overlapping this ancient shore-line, but the results of the examinations of the mountains lately carried on by Dr. Dawson and others have shown no reason to suppose that they were then at all folded, but rather seem to indicate that they were merely a comparatively undisturbed land area through which rivers might flow to the nearest ocean. Lime is present in large quantity in the rocks of the Edmonton Series, and it was probably derived from the Devonian and Carboniferous limestones which doubtless came to the surface over part at least of the above area, an area of course very much larger than that now occupied by the Rocky Mountains, but the materials of which the sandstones are composed are not such as could have been derived from these overlying limestones or even from the underlying quartzites and slates, but consist largely of felspar, with some quartz, mica, and a decomposed ferruginous mineral, probably magnetite, or such as might be expected to be derived from the degradation of granitoid rocks.

A wide belt of such rocks exists in the present Selkirk or Gold range, just west of the Rocky Mountains. It would seem not improbable, therefore, that rivers rose in this range and flowed eastward across the intervening land area into the sea in which the Edmonton Series was being deposited, carrying with them the sand derived from the rock over which they flowed in the upper part of their courses, and with this saud would be mingled a large quantity of calcareous material washed from the sedimentary palæozoic beds composing the banks in their stretches.

In this case the gold found in the North Saskatchewan would have been originally derived from the wearing down of the gneisses and granites of the Selkirk Mountains, from which numerous small streams are still carrying gold into the wide valleys that run along their eastern and western sides. Gold derived from Selkirk Mountains.

PASKAPOO SERIES.

Under this heading we group all the Laramie rocks lying above those of the Edmonton series; thus it will include Dr. Dawson's Porcupine Hills and Willow Creek series, and all but the lowest 700-900 feet of his St. Mary river series. On the plains, no place was seen where its total thickness could be measured, but at the outer edge of the foot-hills, on Little Red Deer River, a thickness of 5,700 feet at least was determined, the bottom of the formation Thickness of series.

not being seen, and it is probable that a considerable thickness had been denuded from the top.

Character of the formation.

The beds consist of more or less hard, light-grey or yellowish, brownish-weathering sandstone, usually thick-bedded, but often showing false bedding; also of light bluish-grey and olive sandy shales, often interstratified with bands of hard lamellar ferruginous sandstone, and sometimes with bands of concretionary blue limestone, which burns into an excellent lime. The sandstones consist of very irregular, though slightly rounded, grains of quartz, felspar, and mica, cemented together in a calcareo-argillaceous matrix.

List of fossils.

The whole series, as shewn by its invertebrate fauna, is of fresh water origin. In this district the following fossils have been found in it:—

Unio Danæ, Meek and Hayden.
Sphærium formosum, var.
Limnæa tenuicostata, Meek and Hayden.
Physa Copei, White.
Acroloxus radiatulus, Whiteaves.
Thaumastus limnæiformis, Meek and Hayden.
Goniobasis tenuicarinata, Meek and Hayden.
Hydrobia, sp.
Campeloma producta, White.
Viviparus Leai, Meek and Hayden.
Valvata filosa, Whiteaves.
Valvata bicincta, Whiteaves.

Of fossil plants the following have been found:—

Onoclea sensibilis, Linn.
Sequoia Nordenskioldii, Heer.
Sequoia Langsdorfii, Heer.
Sequoia Couttriæ, Heer.
Taxodium occidentale, Newberry.
Platanus nobilis, Newberry.
Corylus McQuarrii, Heer.
Quercus, sp.
Populus acerifolia, Newberry.
Populus Richardsoni? Heer.
Populus arctica, Heer.
Ficus, sp.
Salix Laramiana, Dawson.
Viburnum asperum, Newberry.
Viburnum Saskatchuense, Dawson.
Catalpa crassifolia, Newberry.
Sapindus, sp.

Carya antiquorum, Newberry.
Juglans, sp.
Nelumbium Saskatchuense, Dawson.

Extent of the formation. Within the district north-east from the edge of the disturbed region, this series occupies a belt seventy to a hundred miles wide, and in the foot-hills themselves, it constitutes entirely the outer anticlinal, and within that, it is folded in with the Pierre and older beds. Outside the district it has been traced along with the Edmonton series as the Laramie or Lignite Tertiary formation, by Drs. Richardson, Selwyn, Dawson and Bell, southward to the Boundary Line, eastward to the Turtle Mountain in Manitoba, and northward to the Arctic Circle in the valley of the Mackenzie.

Age of Laramie In reference to the age of the Laramie, including its two subdivisons, some interesting discoveries have been made. In ascending from the Pierre group, which is clearly of Upper Cretaceous age, we pass gradually from beds of purely marine origin to the Edmonton series, which was laid down in shallow brackish water in an almost land-locked bay, or in a great salt marsh near the mouth of a large river. This is shown by the presence of numerous beds of coal, of many fragments of land plants and leaves, of brackish-water molluscs, and great numbers of bones of land Dinosaurs, which have evidently been entombed in the beds over which they waded or in the marsh on or along the edge of which they used to feed or hunt their prey.

Shore line of Edmonton sea. The shore line that bounded towards the west this shallow water or marsh ran between the present western outcrop of the Edmonton series and the position of the foot-hills, though further south, according to Dr. Dawson, these beds extend through the present position of the foot-hills into the mountains, which were, however, not then upraised; but in the district under consideration, the region of the foot-hills was raised slightly above the sea level, though not to such an extent as to suffer any appreciable amount of erosion, and was, doubtless, cut through by rivers that brought down sediment from the higher land to the west, and spread it out over the marshes near the shore as stated on a previous page.

Mountains uplifted at close of Edmonton period. At the close of the Edmonton period, the pressure which had caused the uprising of the present plains-area from the bottom of the Pierre sea, and which towards the west had raised the land completely above the surface of the water, was relieved by the uplifting of the Rocky Mountains along a line near the western edge of this great area, and the "Plains" sank again beneath the surface of the sea, now cut off entirely from the main ocean and converted into a great inland lake, and a thickness of several thousand feet of sandstones and sandy shales,

was laid down on the gradually sinking floor, these sandstones and shales being the Paskapoo series of this report. In these beds, no Dinosaurian remains have been discovered, but we find in them a considerable number of land plants, and land and fresh-water molluscs, with occasionally beds of coal.

Period of elevation at close of Laramie.

At the close of the Laramie, another period of elevation was ushered in; the foot-hills were folded into something like their present condition, and a great thickness of the Laramie was denuded before the Miocene of the Hand Hills was deposited on it.

Cretaceous closes with Edmonton series.

Judging, therefore, from the facts that the Edmonton series is composed of but from 600 to 700 feet of sands and clays, which have been rapidly deposited conformably on the top of shales of Upper Cretaceous age; that the flora and invertebrate fauna of this period are very similar to those of the Belly River series, which distinctly underlies the Pierre; that, at the same time, Cretaceous types of Dinosaurs continued to flourish; that, at the end of this period, these latter forms died out, and a time of great disturbance ensued, in which the Rocky Mountains were uplifted, it seems reasonable to place the close of the Cretaceous Epoch at the time of deposition of the topmost beds of the Edmonton series; and that the Tertiary Epoch began with the commencement of the Paskapoo period, during which a great thickness of sandstones and sandy shales was laid down without any apparent break or unconformity. In this Paskapoo series then, we have the representative of the Eocene of Europe.

MIOCENE.

Composition.

Resting on the denuded edges of the Laramie in the Hand Hills, are beds of light-grey argillaceous marls interbedded with fine-grained sands, which pass upwards into a bed of quartzite pebbles, in some places held together by a hard calcareous cement, and forming a compact conglomerate. On the west side of the hills this stands out boldly at the top of the escarpment, giving the impression when seen from a distance, of a horizontal band of hard sandstone.

These rocks have already been referred to on page 78 E in describing the geology of the Hand Hills.

No fossils.

Though fossils were carefully searched for throughout the formation, none were found, but there is little doubt, considering its position and character that it is of the same age as the Miocene of the Cypress Hills, which was first examined by Dr. Hector, in the summer of 1859, and briefly described by him,* though its exact age, thick-

* Journals, Detailed Reports, and Observations, relating to the Exploration by Capt. Palliser. London, Government, p. 221, and Q. J. G. S., Vol. XVII. p 399.

ness and distribution, was not known till the Cypress Hills were visited by Mr. McConnell, in 1884.

Post–Tertiary.

Overlying the greater part of the area examined, is an extensive, though generally thin, sheet of superficial sands, clays and gravel, which fill in and level up many of the irregularities in the surface of the Cretaceous and Laramie rocks, though, as in the case of many of the rolling hills, they have also served to add to the surface irregularities.

In the district to the south, Dr. Dawson has divided these deposits into several fairly distinct sub-divisions, and as these can, in many cases, be also distinguished in the area under consideration, his table is here given: *

Divisions of superficial deposits.

"Stratified sands, gravels and silts.
Upper boulder-clay.
Interglacial deposit with peat.
Lower boulder-clay.
Quartzite shingle and associated beds."

Bed of quartzite shingle.

The quartzite shingle consists of a deposit from two to twenty feet in thickness of well-rounded, water-worn quartzite pebbles, about the size of small cobblestones, imbedded in a matrix of soft sand. This pebble bed rests everywhere immediately on the surface of the underlying Laramie, having been deposited at various elevations in lake or river beds in the epoch immediately preceding that in which the country was buried under a great continental glacier or glacial sea. The distribution of the quartzite shingle has already been traced and described by Dr. Dawson from near the mouth of St. Mary River to the Bow River, at the mouth of the Highwood, and it remains here to describe it northward to the North Saskatchewan.

On the Little Red Deer River it was first seen a short distance below the mouth of Dog Pound Creek, where a thickness of fifteen feet underlies the boulder-clay at an elevation above the sea of 3,300 feet. On Red Deer River, gravel terraces and flats are common in the upper part of its course, but these were not seen to be overlain by boulder-clay till a bank a short distance below the crossing of the Rocky Mountain House trail was reached at an elevation of 3,150 feet. Here the pebble bed rests immediately on the sandstones of the Laramie, and is overlain by the bottom beds of the boulder-clay, as shown in the following section:

Gravel terraces

* Geol. Survey Report for 1882-84, p. 140 C.

	FEET.
Light-coloured, roughly stratified sandy clay with numerous pebbles	5
Stratified sand becoming slightly clayey towards the top and containing a few pebbles	7
Rather hard dark-coloured unstratified boulder-clay containing pebbles of quartzite, sandstone and coal, but none of gneiss	17
Bed of quartzite pebbles, with soft sandy matrix, unstratified, except that the pebbles are lying with their greater axes horizontal. The line between this bed and the one above it is very sharp	20
Sandy shales and sandstones	8
	57

Below the above point, the pebble bed is seen almost constantly in the banks of the river to a short distance below the mouth of the Blind Man, where it is cut off by a ridge of Laramie hills, through which the river has worn a steep narrow gorge. All the sections seen are essentially the same as that given above.

On North Saskatchewan River.

In the valley of the North Saskatchewan River, the pebble bed is seen at an elevation of 3,000 feet, a few miles above the mouth of Baptiste River, overlain by boulder-clay, and again, a short distance below Edmonton, a similar quartzite pebble bed eight feet in thickness overlies rocks of the Edmonton series and merges above into stratified sand, forming in all a bed twenty feet in thickness. This again is overlain by dark columnar boulder-clay, the lower edge of which is sharply defined against the stratified sand below.

On Battle River

On Battle River, gravel, apparently also of this age, underlies the level country west of Todd's Crossing, being here generally overlain by the more stratified upper portion of the boulder-clay, though the lower columnar part is also seen in some places. At one point a short distance south of where Battle River flows into the wide valley of Pipestone Creek, a bed of gravel twelve feet thick, in which, however, there appears to be a slight admixture of small pebbles of gneiss, underlies the boulder-clay, and generally rests on the surface of the Laramie, but in one place, as stated on page 85 E, the otherwise horizontal surface of the Laramie is hollowed out for a depth of about our feet, and the depression is filled with large boulders of gneiss and quartzite, mingled with nodules of clay ironstone.

Origin of the gravel deposits.

It is probable that the material of the gravel seen in the upper parts of the streams, nearer the mountains, is derived directly from the Palæozoic quartzites in the Rocky Mountains, and it is also probable that all the material of the quartzite pebble beds on the plains were originally derived from the same source, but in the case of the

shingle beds near Edmonton as well as of those on Battle River, it would seem that their material has been immediately derived from some areas of older conglomerate, perhaps of Miocene age, that formerly covered the top of the Beaver Hills, but have long since been denuded and redistributed over the less elevated country. The gneissoid boulders, however, that are seen to underlie the shingle near Battle River must have been brought from the north or north-east by a stream that flowed southward from the Archæan continental nucleus. This would be quite in accord with the theory of the southern elevation of the continent in the Post-Pleiocene times, a theory for which many other and independent proofs have been advanced.

In the Battle River valley, near the mouth of Iron Creek, a thick deposit of quartzite gravel of more recent date underlies a considerable area. It has doubtless been derived from some beds of older conglomerate that probably covered the country in the vicinity of Flagstaff Hill. Deposit at mouth of Iron Creek.

Resting on the surface of all the older strata, including the pebble-bed just described, the boulder-clay covers a great part of the district east of the foot-hills. Towards the west it is generally divisible into two fairly distinct portions, while further east, the characters that distinguish the two subdivisions do not obtain, and at present it must be considered simply as one deposit. Nowhere throughout the district, however, is this boulder-clay deposit known to be of any great thickness; it would not average more than from twenty to thirty feet, while in many places it has been entirely denuded, leaving the Laramie and Pierre clays close to the surface or covered only with a few feet of earth derived from the disintegration of the underlying beds. But the valleys cut by most of the streams are so shallow, and the banks are so sloping, that very often there is no sign of the underlying rocks. Boulder clay.

This boulder-clay is composed of a more or less sandy clay generally firmly compacted together, and holding pebbles and boulders which in the western portion are largely composed of quartzite, though some of gneiss are almost always present, but further out on the plains the percentage of quartzite pebbles becomes very much reduced, and pebbles of sandstone become comparatively numerous; almost everywhere, too, fragments of lignite derived from the underlying rocks are present. Composition of boulder-clay.

The deposit is generally massive in character, but often, in its upper portion, shows indistinct signs of stratification, while the lower portion is intersected by numerous jointage planes, so that where a bank is being rapidly washed away it presents an almost perpendicular face, with a roughly columnar, rather than an even surface. Physical character.

The prevailing colour is a bluish or yellowish grey, but the lower beds are generally much darker from the presence of fragments of coal as mentioned above.

The larger streams almost everywhere cut through this boulder deposit, the only exception being the North Saskatchewan, near the mouth of Beaver Creek, where the banks are less than a hundred feet high, and Rosebud Creek, about the middle of its course, where the banks have a height of eighty feet.

Western limit. The western limit of the boulder-clay appears to coincide closely with that of the underlying quartzite gravel, but this is doubtless either because the gravel has been washed away when not protected by a covering of clay, or because we have not been able to separate the recent from the more ancient gravel beds, where the overlying glacial deposits are absent. This western limit follows roughly the 3000 feet contour line, rising, however, towards the south three or four hundred feet above it.

On Little Red Deer River. In descending Little Red Deer River, boulder-clay is first seen near the mouth of Dog Pound Creek, where it overlies the pebble bed with a thickness of twelve feet, while on the latter creek, it crops out along the sides of the wide sloping valley for several miles above its mouth.

On Red Deer River. On Red Deer River, the first section observed was that given on page 138 E, where the drift exhibits the typical characters of the upper and lower subdivisions, separated by a bed of stratified sand. Near the mouth of Blind Man River, the uppermost subdivision of the superficial deposits is exposed, as a band ten feet thick, of light-grey, rather hard, stratified silt, immediately overlying the dark-coloured lower boulder-clay, and forming a projecting ledge, the line between these two latter beds, however, not being sharply defined. Towards the northwest, near the head waters of the Blind Man and Medicine rivers, dark-grey sandy boulder-clay covers the surface, while on the other side of the watershed, near the source of Wolf Creek, similar clay with included gneissoid boulders, forms in places the bank of the stream.

On North Saskatchewan River. On the North Saskatchewan many gneissoid boulders are scattered along the bed of the river as far up as the mouth of Baptiste River, and to a short distance beyond it, where the following section was observed in the sloping bank:—

	FEET.
Light-grey bedded clay	8
Covered	30
Dark-coloured jointed sandy clay containing pebbles of coal, quartzite, gneiss, etc.	6
Bed of quartzite pebbles	14
Lamellar light-grey sandstone	2

East and north of the line thus roughly outlined by the above exposures, the boulder-clay covers the country more or less continuously, the Hand Hills being the only area on which it appears never to have been deposited. Its thickness is, however, very unequal, being much greater in the pre-glacial hollows in the Cretaceous and Laramie rocks, than on the tops of the hills that had been formed when these underlying rocks were being worn down to their present level.

The stratified sands and silts overlying the true boulder-clays have also played a very important part in filling up ancient depressions. As the front of the great continental glacier receded towards the north, or when the water was retiring at the close of the glacial epoch, large lakes filled the depressions in the uneven surface of the country, and into these lakes the drainage of the surrounding land was carried, and its included sediment settled to the bottom forming beds of fine stratified sand and clay. Similar beds must be forming now on a small scale in the little lake at the bend of Battle River, between Todd's Crossing and the "Leavings," as the river flows into it loaded with sediment, but leaves it beautifully clear, having dropped all its mud among the weeds in the shallow lake. Beds of this character are well seen on Red Deer River, near the crossing of the Calgary-Edmonton trail, and on Rosebud Creek, about the middle of its course. On the latter stream, the following interesting sections were observed:— Stratified sands and silts.

Lignite in boulder-clay.

	FEET.	INCHES.
Banded and almost shaly light-grey clay	15	0
Compact clay	12	0
Sandy clay with boulders	15	0
Pure stratified sand	40	0
	82	0

And at a short distance further east:—

Bedded shaly clay, at the top		
Sandy boulder-clay	20	0
Irregular seam of lignite	0	1
Whitish sandy boulder-clay with a few small pebbles, and a thin seam of ironstone	4	0
Clayey sandstone	8	0
	32	1

This is the only place in this district where a seam of lignite was noticed in the boulder-clay, though Dr. Dawson has recorded it from several places in the region to the south.

A short distance below Edmonton, on the North Saskatchewan, some very interesting sections of the superficial deposits have also been seen. Irregular drift on North Saskatchewan River.

From Edmonton to the mouth of Sturgeon River, from fifteen to twenty-five feet of columnar dark-coloured sandy drift occupies the top of the bank, underlain by about twenty-five feet of stratified sand and gravel. At the mouth of Beaver Creek, the banks of the North Saskatchewan are seventy feet in height; they are composed of yellow sand and are interbedded with blue shaly clay containing pebbles of gneiss, quartzite, ironstone, etc., while the top is a sandy clay containing large gneissoid boulders. These sands and clays are newer than the true boulder-clays, being composed of material largely derived from them; they are probably of the same age as the bedded clays, and not improbably also as those of the older drainage channels shortly to be described.

On the Plains east of the 113th meridian, the surface is generally covered with a few feet of drift, but this deposit is not known to be anywhere of any very great thickness, as most of the streams have cut through it into the underlying rocks. Over considerable areas, however, it has been piled up very irregularly; for instance, in the Neutral Hills it has played an important part in giving the country its present hilly aspect. The same may also be said of the Blackfoot Hills; and the Beaver Hills are simply rounded drift knolls that have been laid down on an elevated ridge of the underlying Laramie rocks, or against the edge of a plateau that has since been washed away.

Irregular "rolling" hills.

On the southern and eastern sides of the Hand Hills, on the south side of the Wintering Hills, and in a few other places, the drift assumes the form of round-topped hills, sometimes as much as two hundred feet high, with a roughly circular contour, separated by deep grassy depressions in the bottom of which lie little fresh-water lakes, none of which have any outlet. Very few sections were seen in these hills, but those which were seen showed boulder-clay similar to that overlying the more level parts of the country.

Sand hills.

Considerable areas are also covered with loose yellow sand, either as drifting sand hills such as those lying south of Rosebud Creek, south of Battle River near the mouth of Ribstone Creek, and the low sandy ridges that run across the plains near the head of Sounding Creek; or as more consolidated sand, such as that of the wooded hills north of the Neutral Hills, and over a considerable stretch of country still further north. The Beaver Hills are also overlain by a sandy covering derived, doubtless, from the disintegration of the underlying drift; and on Clearwater River and Prairie Creek, towards the foot-hills, long ridges of coarse yellow sand, covered with cypress and juniper, run parallel with their eastern edge.

Distribution of boulders.

Wherever the boulder-clay comes to the surface, and on many of the higher ridges on which it has been in all probability but thinly depo-

sited, and has since been washed away, large and small boulders of gneiss, doubtless of eastern origin, cover the surface. On the plains, these boulders are collected and exposed in great numbers around the edges of lakes, as well as on the summits of all the higher elevations. This is especially the case on the Neutral Hills, the summits of which, and, in fact, of all the surrounding higher lands, are covered with a great profusion of boulders of gneiss and limestone, while on the sides of the hills there are many small pebbles of chert. Either these hills were formed in the glacial sea in shallow-water where numbers of icebergs stranded and dropped their load of pebbles and boulders to the bottom, to be afterwards rounded by atmospheric agencies when the country rose above the level of the water; or the stratum of boulder-clay or till that was deposited by the continental glacier, has had the greater part of its finer sediment washed down to a lower level, leaving the large boulders on the tops of the hills. On the summit of Blackfoot Hills a few gneissoid boulders are scattered, but on Beaver Hills very few boulders are seen except around the lakes as they have probably been buried under the many beaver meadows which fill most of the valleys. Gneissoid boulders are also numerous on the top of Medicine Lodge Hills at an elevation of 3,415 feet, on the ridge east of the crossing of the western Wolf Creek, and on the sides of the ridge at the head of the west branch of Medicine River at an elevation of about 3,200 feet. Mr. Hamilton, my assistant, in 1885, stated that he found a gneissic boulder also at about the latter elevation on the trail leading southward from Rocky Mountain House.

Unglaciated tract on Hand Hills.

The top of the Hand Hills shows no signs of glaciation, but at an elevation of about 3,200 feet, the surface begins to break into rolling hills, which represent either the shore line of the glacial sea or a morainic deposit along the edge of the great glacier. The country around the foot of the hills, as well as around the Wintering Hills, is thickly strewn with quartzite pebbles, evidently derived from the Miocene conglomerates that now cap the Hand Hills and may formerly have also overlain the Wintering Hills.

River terraces.

Terraces are seen on the upper parts of all the principal streams and on the North Saskatchewan throughout the greater part of its course down to Fort Pitt, as well as in some of the old drainage channels that intersect the country, notably in that down which the Vermilion River now flows. These old channels, the principal of which have been enumerated on a former page of this report, have, in the period im-

Ancient river channels.

mediately succeeding the Glacial epoch, carried large streams in an eastward or south-eastward direction from the mountains or their vicinity. Now their banks are sloping and grassy and they are drained by very small streams, or their bottoms are occupied by narrow

lakes. Where these old channels connect with those in which large rivers at present flow, the streams, in every case, appear to have been diverted from more southern to more northern courses, as will be seen by following out on the accompanying map some of the valleys mentioned below.

The valley that runs south-eastward from the Elbow of Clearwater River is one of these old drainage channels, and once carried the waters of the Clearwater southward into the Red Deer. It is wide and sloping, several very well defined terraces extending along the hills on either side.

East branch of Blind Man River.

The east branch of Blind Man River also flows in one of these old channels; its source is in the bottom of the valley, in a deep marsh which is drained by two streams flowing in opposite directions and discharging respectively into the Red Deer and into the North Saskatchewan. Just south of the twelfth Base Line, a wide grassy plain, forty feet above the level of the marsh or "muskeg" at the watershed, stretches for several miles along the west side of the stream. The surface of this plain is composed of yellow sandy clay, beneath four feet of which is a deposit twenty feet or more in thickness, of rounded, water-worn quartzite pebbles. These pebbles have evidently been brought down from the quartzite rocks of the mountains by the stream that flowed through the valley, and were

Gravel deposit.

spread over the bed of its channel, which at the time expanded here into a shallow lake. Precisely similar deposits have been comparatively recently formed on many of the rivers flowing from the mountains, as for instance, on the Bow River at Calgary, and on the North Saskatchewan at Rocky Mountain House.

The valleys of the upper Battle River, of Black Mud, Pipestone and Tail creeks are also ancient river channels. The valley of Vermilion River which, towards the north-west, joins or more prob-

Vermilion River valley.

ably crosses the North Saskatchewan valley, and, towards the south-east, runs into Grizzly Bear Coulée and the Battle River valley, is an old channel that must have carried a large stream eastward, for it is in many places very wide and deep, with well defined terraces. The valley through which the present stream discharges northward into the North Saskatchewan, is narrow and ill-defined, with steeply scarped banks towards its mouth, and has evidently been much more recently formed than the wide valley through which it flows south-eastward from the "Chain of Lakes."

Age of ancient river channels.

Whether these valleys date back as far as the bedded clays or not, it is impossible to say at present, on account of the extreme rarity of sections along their sides, but they show clearly an ancient drainage system anterior to the present one, when, perhaps, the rain-fall was

heavier than it is now and considerable accessions were made to the volumes of the streams after they had left the mountains. At present these valleys are being gradually filled up by detrital material washed in from either side, the force of the water, in the existing streams, not being sufficiently great to carry away all the sediment that is being brought down into them.

ECONOMIC MINERALS.

Coals and Lignites.—The enormous deposits of coal and lignite that underlie an area of more than 12,000 square miles in the western part of this district must be considered as first in value and importance among its economic minerals. Analyses of specimens collected from the different seams near their principal outcrops are found on preceding pages, while fuller descriptions and analyses are included in Mr. Hoffmann's report, Past T. Reference might also be made to Dr. Dawson's chapter on coals and lignites in his "Report on the Region in the vicinity of the Bow and Belly rivers,"* where much useful information with regard to western coals and lignites is recorded. **Coals and lignites.**

The only true bituminous coal yet found within the district is that outcropping on the edge of the disturbed belt on the eastern side of the first anticlinal seen, as the mountains are approached in ascending the Bow valley. On the north side of the river, one seam two feet ten inches thick was all that was observed, with a strike S. 19° E. and an eastward dip of 30°. The specimen analysed from this outcrop was found to contain a large percentage of ash, while a specimen sent from the opening on the south side of the river, contained less than half as much; but this latter specimen represented, in all probability, the best part rather than the average of the seam. **Bituminous coal on Bow River.**

Taking the thickness of the coal south of the river as seven feet, and assuming that the dip gradually decreases to the eastward, this seam would contain about 9,500,000 tons of coal per square mile.

The extent of this coal-bed to the north and south has not yet been worked out, but there is every reason to suppose that it will be found stretching for many miles on either side of its present known outcrops.

Nearest in character to the bituminous coal, are the lignitic or semi-bituminous coals found on the Red Deer River at the eastern edge of the foot-hills, and in the comparatively undisturbed beds at Rocky Mountain House on the North Saskatchewan, both like the seam on Bow River, in the Paskapoo or upper subdivision of the Laramie. The seam on the Red Deer is almost vertical and so much broken and slick- **Lignitic or semi-bituminous coal.**

* Geol. Survey Report for 1882-84, pp.

ensided that it was very difficult to make out its exact length. It occurs on the continuation of the same anticlinal as the seam at Coal Creek, and, probably, represents the same horizon. It contains a little more hygroscopic water than the coal from this latter seam, but a considerably smaller percentage of ash.

Seam at Rocky Mountain House. The seam at Rocky Mountain House is very irregular, being at the mouth of the Clearwater but eight inches thick, while a mile and a half further north on the North Saskatchewan, it measures from two to three feet. It has a much larger percentage both of water and ash than that from the Red Deer, but is still very compact and capable of being transported for long distances without breaking into fragments. It is hardly possible that this seam can be worked economically at any of the known outcrops, for more than local use, but it is not improbable that other and thicker outcrops may be found in the vicinity from which a large supply could be mined.

Lignite-coals in Paskapoo series. Of lignite coals the only seam of any considerable thickness at present known in the Paskapoo series, outcrops on the North Saskatchewan twelve miles above the mouth of Yapeoo or Buck Creek in township 49, range 7, west of the fifth principal meridian. The outcrop of this seam is very much obscured by land-slides, but in one place a thickness of fifteen feet of lignite coal was measured and the bottom of the seam was not seen. In another place, five miles distant, the seam was seen to have a thickness of eight feet. Taking, therefore, eleven and a half feet as the mean thickness of this seam throughout the five miles down the river, and assuming that it extends for at least a mile on either side of the river valley, this area would be underlain by 140,000,000 tons of lignite coal. This appears to be the same coal horizon that is represented by a thin seam both on the upper part and near the mouth of Paskapoo or Blind Man River and at the trail crossing on Rosebud Creek.

Lignite-coals in Edmonton series. At the top of the Edmonton series, between four and five hundred feet below the last mentioned seam, there is a very persistent coal horizon that is seen cropping out on the North Saskatchewan with a thickness of twenty-five feet, on the Red Deer with a thickness of ten feet, on Devil's Pine Creek with a thickness of four feet and a half, on Three Hills Creek with a thickness of over two feet, and on Knee Hill Creek with a thickness of four feet. It is impossible, at present, to compute the enormous amount of lignite to be found in this extensive deposit, but the following figures may be given as the quantity that may be relied on with considerable certainty as occurring in the immediate vicinity of some of the above outcrops.

On the North Saskatchewan, the seam was seen to extend in a straight line for three miles retaining its thickness of twenty-five feet; and for

several miles further, large outcrops were seen that could not easily be measured. It was also, in one place, seen to extend a mile back from the river. If we take then a length of three miles of this seam, a width of a mile on each side of the valley, and a thickness of twenty feet, in order to allow for any local constrictions, this small area would be found to contain over 150,000,000 tons. On the Red Deer River the seam contains about 12,500,000 tons per square mile; on Devil's Pine Creek, 5,500,000 tons per square mile, on Knee Hill Creek, 5,000,000 tons per square mile, and in the valley of this latter stream, the seam was traced for from two to three miles down the creek. The line of outcrop of this seam has, therefore, been traced more or less continuously for one hundred and eighty miles, and as will be seen by referring to the preceding pages, the lignite coals at all the outcrops was of good quality.

Thick seam in North Saskatchewan River.

Throughout the Edmonton series, there are various other coal seams of greater or less extent, many of which will be opened as the country becomes more fully developed; but the one that appears to be most persistent is found at a height of about one hundred and sixty feet above the bottom of the series. At the mouth of Rosebud Creek, this seam was found to have a thickness of six feet ten inches, while on Battle River and Meeting Creek, it has a thickness of four feet, representing 5,000,000 tons per square mile. This is essentially the same coal horizon that is again seen at Edmonton, on the North Saskatchewan, though it is hardly likely that the same seam is continuous throughout.

Comparison with American coals.

As regards the quality of the lignite coals here met with, analyses and descriptions of specimens from the principal and typical seams are given in the chapter on Descriptive Geology, where the outcrops are referred to, and their general characters are so similar to those already described by Dr. Dawson and Mr. Hoffmann, from the Bow and Belly rivers district, that it is unnecessary to describe them again here.

Many of the coals will compare very favorably with those mined in Eastern America, while the coals and lignites generally are qutie equal to those now so largely used in Colorado, Wyoming and other western States.

In the former state,* the total output for 1884 was 1,130,024 short tons, of which the mines at Cañon City yielded 167,995 tons. In 1885 these mines yielded 327,038 tons. "The coal ranks first in the state for all domestic purposes, and is largely used in Denver, while Cañon City and

* The figures and analyses given below are taken from *Mineral Resources of the United States*, 1883-84. Albert Williams, Jr., Washington, Government, 1885, pp. 27-38 and 100-104, and *Mineral Resources of the United States*, 1885, Albert Williams, Jr., Washington, Government, 1886, p. 25.

Pueblo derive their supply almost entirely from these mines." The following is one of the analyses given for this coal:—

	PER CENT.
"Moisture	6.72
Volatile matter	34.76
Fixed carbon	52.70
Ash	5.82
	100.00"

By referring to analyses given in preceding pages of this report, it will be seen that the coal from Coal Creek, near Bow River, as well as that from the edge of the foot-hills on Red Deer River, are not at all inferior to the above, while that from Rocky Mountain House compares very favourably with it.

In 1884, the mines near Erie and Canfield yielded 102,955 tons, and the following analysis is given as showing their general character:—

	PER CENT.
"Water	14.80
Volatile matter	34.50
Fixed carbon	47.30
Ash	3.40
	100.00"

This lignite coal is evidently inferior to that found at Edmonton and on Meeting Creek; it has an amount of water in its constitution equal to or greater than that from any of the seams within this district, though some of these latter contain a much larger percentage of ash than is shown in the above analysis.

In Wyoming, the total output for 1884 was 902,620 short tons, consisting of coals and lignites containing amounts of moisture varying from 6.10 to 15.40 per cent., and showing otherwise general characters very similar to those of the coals and lignites treated of in this report.

Ironstone on Red Deer River

Iron ore.—In some places along the outcrop of the beds of the Edmonton series, and notably on Red Deer River west of the Hand Hills, a large quantity of clay ironstone is scattered over the face of the clay and sandstone banks, and over the surface of the alluvial flats, which stretch between them and the river. Samples of ironstone similar to that which is here seen, have been analysed by Mr. Hoffmann, and found to contain from 22 to 34.90 per cent. of metallic iron. It occurs, however, in the rocks in very irregular lenticular bands and nodules, so that after what is lying on the surface had been collected, the work of digging it from the banks would give irregular and uncertain results.

Lime and Cement.—Outside the limit of the mountains there is very little limestone in the district, although in the lower part of the Paskapoo series, there are some hard nodular bands which when struck break into irregular angular fragments and which, in some cases, burn down into an excellent lime. Among these bands may be mentioned that on Blind Man River, near the crossing of the Rocky Mountain House trail, and also a band on the banks of the North Saskatchewen River, in township 47, range 9. west of the fifth principal meridian. A good cement could also be made from many of the clayey concretions which are found in immense numbers throughout the shales of the Pierre group. **Nodular limestone.**

Clay.—Clay for bricks and pottery can be found in the boulder-clay in considerable quantity as well as throughout the Pierre and Edmonton series. In the latter, a smooth clay is found which bakes to a fine porcelain-like mass, and will, doubtless, be of service in the manufacture of stoneware. **Brick-clay, etc.**

Building-Stone.—There are few rocks in this district that can be characterized as good building stones, but in some of the Paskapoo beds, and also in some places in the yellow part of the Belly River series, there are hard grey yellow-weathering sandstones that can be used for buildings of moderate size, where permanency is not regarded as the chief consideration.

Gold, in the form of fine particles, is found in the beds of all the principal streams throughout this area, but especially in the North Saskatchewan, where, after the high water of the early part of the summer has subsided, it is washed out to a considerable extent. The years in which the water is highest, are those in which the miners have made the best wages, the reason being simply, that in those years the largest amount of clay and sand either from the boulder-clay or from the Edmonton series, is washed down from the banks into the stream, and broken up and separated by the water, the clay being carried furthest aest to settle in the quieter parts of the river, while the gold is deposited with the sand and alluvial gravel on bars that cross the bottom of the channel, and which are usually left uncovered in low water. **Gold in the beds of the stream.**

It is a common error to suppose that, as gold is very heavy, the most of it will settle in the deepest parts of the bed of the stream, and that only a small portion will remain higher up on the bars. This would doubtless be the case if the nuggets were of considerable size, but in the present instance the particles are exceedingly minute, with very irregular surfaces, and easily held suspended in the water for a compatively long time. It will, therefore, be only in the eddies and quieter **Deposited on the bars.**

parts of the stream, the very places where sand and gravel bars are being formed, that these particles of gold will settle to the bottom. In low water, the river is confined almost entirely between banks of alluvial deposits which are not being washed away to any great extent, so that there is very little gold then carried out into the stream, but what is carried out into it, on account of the quieter state of the water, sinks to the deepest parts of the channel; however, the amount moved at this time must be small in comparison with that carried down in high water, almost all of which is deposited on the bars.

APPENDIX I.

ON SOME FOSSILS FROM THE CRETACEOUS AND LARAMIE ROCKS OF THE SASKATCHEWAN AND ITS TRIBUTARIES, COLLECTED BY MR. J. B. TYRRELL IN 1885 AND 1886.*

BY J. F. WHITEAVES.

(A.) CRETACEOUS SPECIES.

LAMELLIBRANCHIATA.

PTERIA LINGUIFORMIS, var. SUBGIBBOSA, Meek.

Avicula subgibbosa, Meek and Hayden. 1860. Proc. Ac. Nat. Sc. Phil., p. 180.
Pteria subgibbosa, Meek. 1864. Smithson. Check-List N. Am. Cret. Foss.
Pteria linguiformis, var. *subgibbosa*, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 33, pl. 28, fig. 12.

Battle River, township 46, range 4, west of the 4th Principal Meridian, 1885.

INOCERAMUS SAGENSIS, var. NEBRASCENSIS, Owen.

Inoceramus Sagensis, Owen. 1852. Geol. Rep. Wisc., Iowa & Minn., p. 582, pl. 7, fig. 3.
Inoceramus Nebrascensis, Owen. 1852. Ib., p. 582, pl. 8, fig. 1.
Inoceramus Sagensis, var. *Nebrascensis*, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 52, pl. 13, figs. 2 a, b.
Inoceramus Sagensis, Whitfield. Pal. Black Hills Dakota, p. 393, pl. 7, fig. 12, and pl. 8, fig. 2.

Mouth of Vermilion River, township 54, range 3, west of the 4th Principal Meridian; North Saskatchewan River, township 54, range 2, west of the 4th Principal Meridian; Nose Creek, section 24, township 44, range 2, west of the 4th Principal Meridian, 1886: one specimen from each of these localities.

* The fossils collected by Mr. Tyrrell in 1884 have already been enumerated or described in "Contributions to Canadian Palæontology, Part I., 1885."

INOCERAMUS VANUXEMI, Meek and Hayden.

Inoceramus Vanuxemi, Meek and Hayden. 1860. Proc. Ac. Nat. Sc. Phil., p. 180.
Inoceramus Mortoni, Meek and Hayden. 1860. Ib., p. 428.
Inoceramus proximus, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 53, pl. 12, fig. 7; and var. *subcircularis*, Meek, ib., p. 55, pl. 12, fig. 2.
Inoceramus Vanuxemi, Whitfield. Pal. Black Hills Dakota, p. 396, pl. 7, figs. 8, 9, and pl. 8, figs. 4, 5.

Mouth of Vermilion River, township 54, range 3, west of the 4th Principal Meridian, 1886, five specimens; and North Saskatchewan River, township 54, range 2, west of the same meridian, 1886: two specimens.

GERVILLIA RECTA, var. BOREALIS, Whiteaves.

Gervillia recta, var. *borealis*, Whiteaves. 1885. Contr. to Canad. Palæont., vol. I., p. 35, pl. 4, figs. 2, 2 a and 2 b.

Sounding Creek, township 30, range 8, west of the 4th Principal Meridian, 1886: a few characteristic fragments.

TANCREDIA AMERICANA, Meek and Hayden.

Hettangia Americana, Meek and Hayden. 1856. Proc. Ac. Nat. Sc. Phil., vol. VIII., p. 274; and 1860, Ib., vol. XII., p. 185.
Tancredia Americana, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 142, pl. 38, figs. 1, a–h.

Same locality and date as the preceding species: two very imperfect and badly preserved specimens.

CYPRINA OVATA, Meek and Hayden.

Cyprina ovata, Meek and Hayden. 1857. Proc. Ac. Nat. Sc. Phil., vol. IX., p. 144.
" " Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 146, pl. 29, figs. 7 a, b, c, and pl. 30, fig. 11.

Battle River, township 40, range 13, west of the 4th Principal Meridian, and township 40, range 15, west of the same meridian, 1885: a single and barely recognizable specimen from each of these localities.

CYPRINA SUBTRAPEZIFORMIS. (N. Sp.)

Shell small, inequilateral, transversely subtrapezoidal: valves moderately convex, most prominent on the posterior umbonal slopes, which are subangular: height (in the centre) one-third greater than the maximum breadth: length a little more than one-fourth greater than the height. Anterior side short and evenly rounded: posterior side about three times as long as the anterior, its extremity obliquely truncated above and somewhat bluntly pointed below: superior border descending rather abruptly in an obliquely convex curve in front of the beaks, and nearly straight and parallel with the ventral margin behind them: umbones swollen laterally, but scarcely prominent: beaks small, appressed and slightly depressed, placed about half-way between the centre and the anterior margin: lunule none: posterior area subangularly inflected, but very indistinctly defined: ventral margin nearly straight for the greater part of its length, but rounding up abruptly at the anterior end and forming an obtusely subangular junction with the posterior margin behind.

Surface marked with rather coarse, concentric lines of growth: test somewhat thin. Anterior muscular impression subovate: posterior muscular impression rather larger and more nearly circular: pallial line simple and entire: hinge dentition unknown.

Dimensions of the most perfect specimen collected: maximum length, twenty-three millimetres and a half; greatest height, fifteen mm; approximate thickness through the closed valves, ten mm.

Battle River, township 46, range 4, west of the 4th Principal Meridian, 1885: apparently abundant. About thirty specimens were collected at this locality, but of these, only one is quite perfect, with the whole of the test preserved, while the rest are for the most part little more than mere casts of the interior of the closed valves, with portions of the exfoliated test adherent thereto.

The hinge dentition being unknown, it is uncertain to what genus this shell should be referred. It may prove to be a *Cypricardia* or a *Veniella* rather than a *Cyprina*.

PROTOCARDIA SUBQUADRATA, Evans and Shumard.

Cardium subquadratum, Evans and Shumard. 1857. Trans. Ac. Nat. Sc. St. Louis, vol. I., p. 39.

Protocardia (*Leptocardia*) *subquadrata*, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 175, pl. 29, figs. 8 a, b, c, d, e.

Protocardia subquadrata, Whiteaves, as of Shumard. 1885. Contr. to Canad. Palæont., vol. I., p. 41, pl. 5, figs. 4 and 4 a.

Sounding Creek, township 30, range 8, west of the 4th Principal Meridian, 1886: a few well preserved and characteristic specimens.

PROTOCARDIA BOREALIS, Whiteaves.

Protocardia borealis, Whiteaves. 1885. Contr. to Canad. Palæont., vol. I., p. 41, pl. 6, figs. 1, 1 a, 2, 2 a, and 3.

"The Nose," township 27, range 8, west of the 4th Principal Meridian, 1885: two specimens.

LINEARIA FORMOSA? Meek and Hayden.

Tellina formosa, Meek and Hayden. 1860. Proc. Ac. Nat. Sc. Phil., vol. XII., p. 179.
Abra (?) formosa, Meek. 1864. Smithson. Check-List N. Am. Cret. Fossils, p. 14.
Linearia (?) formosa, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 199, pl. 30, fig. 2.

Sounding Creek, township 30, range 8, west of the 4th Principal Meridian, 1886: a perfect right valve of a small Tellinid which corresponds remarkably well with Meek's figure of the above-named species. In the specimen collected by Mr. Tyrrell, however, only the outer surface is exposed to view, the whole of the characters of the interior being buried in the matrix. No traces of any radiating striæ can be discovered on its test, with a lens, although the markings on its outer surface are beautifully preserved, and its test does not appear to have been "*very* thin."

PHOLADOMYA SUBVENTRICOSA, Meek and Hayden.

Pholadomya subventricosa, Meek and Hayden. 1857. Proc. Ac. Nat. Sc. Phil., vol. IX., p. 142.
Pholadomya subventricosa, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 217, pl. 39, figs. 8, a, b.

North Saskatchewan River, at Fort Pitt, and in township 54, range 2, west of the 4th Principal Meridian, 1886: one nearly perfect specimen with both valves preserved from each of these localities. A portion of a mould of a shell which may have belonged to this species, was collected on the banks of the same river near the mouth of Moose Hill Creek.

Dr. Hector records finding a *Pholadomya* which he refers to *P. occidentalis* of Morton, but which is probably referable to this species, at Fort Pitt, on the North Saskatchewan, and at the elbow of the South Saskatchewan, in 1857 or 1858.

LIOPISTHA UNDATA, Meek and Hayden.

Pholadomya undata, Meek and Hayden. 1856. Proc. Ac. Nat. Sc. Phil., vol. VIII., p. 81.
Pholadomya (*Cymella*) *undata*, Meek. 1864. Smithson. Check-List N. Am. Cret. Inv. Foss., pp. 14 and 34.
Liopistha (*Cymella*) *undata*, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 236, pl. 39, figs. 1, a, b.

Nose Creek, township 37, range 9, west of the 4th Principal Meridian, 1885: one characteristic specimen.

SOLECURTUS (TAGELUS) OCCIDENTALIS. (N. Sp.)

Shell transversely elongated, a little more than twice as long as high, very nearly equilateral, strongly compressed at the sides, most prominent on the umbonal slopes, and faintly depressed in the middle below. Anterior and posterior ends both rounded at their margins, but rather more broadly so below than above, while the (presumed) posterior extremity is a very little the narrower of the two. Superior border nearly straight for some distance in front of and behind the beaks, which are inconspicuous, central, appressed and depressed; ventral margin nearly straight or very faintly concave in the centre.

Surface apparently marked only with concentric lines of growth. Hinge dentition, muscular impressions and pallial line unknown.

Approximate dimensions of the only specimen collected: maximum height, twenty-three millimetres; greatest length, sixty-seven mm.; thickness through the closed valves, about fourteen mm.

Battle River, township 40, range 13, west of the 4th Principal Meridian, 1885: an imperfect and badly preserved left (?) valve.

MARTESIA TUMIDIFRONS (N. Sp.)

Shell rather large for the genus, very inequilateral, valves subglobose or semiglobose and abruptly swollen in front, produced and rather rapidly attenuated behind; outline, as viewed from above, somewhat pyriform. Greatest height, as measured in the centre, behind the beaks, about equal to the maximum thickness through the closed val-

ves; greatest height, as compared with the maximum length, about as three to five.

Lateral outline transversely subovate; anterior side very short, its outer margin broadly rounded but somewhat truncated inwardly below the middle; posterior side much more elongated, narrowing gradually at its upper margin and much more rapidly from below upwards, its narrow and conspicuously gaping extremity being apparently somewhat obliquely truncated, though the margins of the cast of the united valves of the only specimen collected are both a little broken at this point. Superior border rounding abruptly downward in front, and nearly straight, but descending very gently behind: ventral margin broadly rounded, most prominent a little behind the middle: umbones swollen and prominent: beaks large, incurved and depressed, with a slight forward inclination and placed very near the anterior end: escutcheon broadly lanceolate and tolerably well defined.

On the umbonal region of the left valve only, a small portion of the test is preserved, and the outer surface of this is marked with concentric and rather irregularly disposed, ridge-like folds, which are often separated from each other by somewhat broader and rather deep concentric furrows. In addition to these, in each valve an elevated but narrow linear ridge runs obliquely backward from the posterior side of the beaks to a little behind the centre of the ventral margin.

Posterior muscular impression narrowly subelliptical, placed very high up, almost within the escutcheon, and a little behind the mid-length; anterior muscular impression, pallial line and accessory valves unknown. The pedal opening in front seems to have been large and broadly rhomboidal in outline.

The measurements of the only specimen collected are approximately as follows: maximum length, about fifty-one millimetres; greatest height, as measured in the centre, immediately behind the umbones, and maximum thickness through the closed valves, both thirty-one mm.

North Saskatchewan River, township 54, range 2, west of the 4th Principal Meridian, 1886: one nearly perfect and well preserved cast of the interior of the closed valves, with a small portion of the test adhering to the left valve. An apparently well characterized and very distinct species.

GASTEROPODA.

Hydatina parvula. (N. Sp.)

Shell small, the outer whorl enveloping all the preceding volutions, strongly inflated and very ventricose, so much so, that its maximum breadth is very little less than the entire height or length—subtruncated

posteriorly, broadest above or behind the middle, narrowing rapidly below or in front and distinctly angular at the base or anterior extremity. Spire narrow, depressed and sunk deeply below the highest level or rounded posterior shoulder of the outer whorl.

Outer lip thin and simple: characters of the aperture and surface markings unknown.

Maximum height or length of the only specimen collected, ten millimetres and a-half; greatest breadth of the same, nine mm.

Sounding Creek, township 30, range 8, west of the 4th Principal Meridian, 1886: one perfect cast of the interior of the shell, with a considerable portion of the inner layer of the test preserved, though the aperture is entirely filled up with the matrix.

This interesting little shell may belong to Conrad's genus *Bullopsis*, rather than to *Hydatina*. It seems to differ from *B. cretacea* of that author in being more expanded posteriorly and more angular in front.

Lunatia concinna, Hall and Meek. (Sp.)

Natica concinna, Hall and Meek. 1854. Mem. Am. Ac. Arts. and Sc., vol. V., p. 384, pl. 3, figs. 2 a, b, c, d.
Natica Moreauensis, Meek and Hayden. 1856. Proc. Ac. Nat. Sc. Phil., vol. VIII, pp. 64 and 282.
Natica (Lunatia) Moreauensis, Meek and Hayden. 1860. Ib., vol. XII., p. 422.
Lunatia concinna, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 314, pl. 32, figs. 11 a, b, c.

Battle River, township 46, range 3, west of the 4th Principal Meridian, 1885: four imperfect and badly preserved specimens. Sounding Creek, township 30, range 8, west of the same meridian, 1886: one specimen.

CEPHALOPODA.

Baculites ovatus, Say.

Baculites ovatus, Say. 1821. Am. Journ. Sc. and Arts, vol. II., p. 41.—Morton. 1829. Journ. Ac. Nat. Sc. Phil., vol. VI., p. 196, pl. 5, figs. 5 and 6; and 1830. Am. Journ. Sc. and Arts, vol. XVIII., p. 249, pl. 1, figs. 6, 7 and 8; also 1834, Synops. Org. Rem. Cret. Group U. S., p. 42, pl. 5, figs. 5 and 6.—Hall and Meek. 1854. Mem. Am. Ac. Arts and Sc., vol. V., (N.S.) p. 399, pl. 5, figs. 1, a, b, and pl. 6, figs. 1-7.—Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 394, pl. 20, figs. 2, a, b, d, and 1, a, b.

Ghost River, township 25, range 6, west the of 5th Principal Meridian, 1885. North Saskatchewan River, near mouth of Moose Hill Creek; also on the same river, in township 52, range 2, and in township 56, range 5, in each case west of the 4th Principal Meridian. Mouth of Vermilion River, in township 54, range 3, west of the same Meridian, 1886.

A few specimens from each of these localities, some of which seem to belong to the typical form of the species, while others are apparently intermediate in their characters between *B. ovatus* and *B. compressus.*

BACULITES GRANDIS, Hall and Meek.

Baculites grandis, Hall and Meek. 1854. Mem. Am. Ac. Arts and Sc., Boston, vol. V., (N. S.) p. 402., pl. 7, figs. 1 and 2, pl. 8. figs. 1 and 2, and pl. 6, fig. 10. Also, Meek, 1876, Rep. U. S. Geol. Surv. Terr., vol. IX., p. 398, fig. 53, and pl. 33, figs. 1, a, b, c.

Sounding Creek, township 30, range 8, west of the 4th Principal Meridian, 1886: two large but fairly characteristic fragments.

BACULITES COMPRESSUS, Say.

Baculites compressus, Say. 1821. Am. Journ. Sc. and Arts, vol. II., p. 41.—Morton. 1834. Synops. Org. Rem. Cret. Group U. S., p. 43, pl. 9, fig. 1; and Journ. Ac. Nat. Sc. Phil., vol. VIII., p. 211.—Hall and Meek. 1854. Mem. Am. Acad. Arts and Sc., Boston, vol. V. (N.S.), p. 400, pl. 5, fig. 2, and pl. 6, figs. 8 and 9.—Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 400, figs. 55 and 56, and pl. 20, figs. 3, a, b, c.

"The Nose," township 37, range 8, west of the 4th Principal Meridian, and Nose Creek, township 37, range 9, west of the same Meridian, 1885.

North Saskatchewan, near mouth of Moose Hill Creek, apparently grading into *B. ovatus*; same river, in township 56, range 5, west of 4th Principal Meridian; mouth of Vermilion River, in township 53, range 3, west of the 4th Principal Meridian: several distorted fragments apparently also passing into *B. ovatus*; North Saskatchewan River, township 54, range 2, west of the 4th Meridian, 1886.

SCAPHITES NODOSUS, Owen.

Scaphites (*Ammonites*) *nodosus*, Owen. 1852. Geol. Rep. Surv. Wisc., Iowa and Minn., p. 580, pl. 8, fig. 4.

North Saskatchewan River, near the mouth of Moose Hill Creek,

1886: a fragment of a mould of the exterior of the shell, which shews the characteristic sculpture of the species, but not enough of the general shape to enable one to say to which of the varieties described and figured by Meek (in the ninth volume of the Rep. U. S. Geol. Surv. Terr.) it should be referred.

PLACENTICERAS PLACENTA, Dekay. (Sp.)

Ammonites placenta, Dekay. 1828. Ann. N. York Lyc. Nat. Hist., vol. II, p. 278, pl. 5, fig. 2 (3 by mistake).—Morton. 1829. Journ. Ac. Nat. Sc. Phil., vol. VI, p. 195; and Am. Journ. Sc. and Arts, vol. XVIII, pl. 2, figs. 1, 2 and 3; also 1834, Synops. Org. Rem. Cret. Form. U. S., p. 36, pl. 2, figs. 1 and 2.

Placenticeras placenta, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX, p. 465, pl. 24, figs. 2, a, b.

Battle River, township 40, range 13, west of the 4th Principal Meridian, 1885: a small fragment.

Sounding Creek, township 30, range 8, west of the same meridian, 1886; a single but nearly perfect specimen which measures nearly nine inches in its greatest diameter.

CRUSTACEA.

PALÆASTACUS (?) ORNATUS. (N. Sp.)

The foregoing is suggested as a provisional name for a rather remarkable specimen of a long tailed decapod, which evidently belongs to the family *Astacomorpha* of Zittel. Of the Cretaceous representatives of this family, it seems to come nearest to such genera as *Palæastacus* and *Hoploparia*, though it differs from each in some important particulars. In many respects it appears to the writer to be still more nearly related to the recent and fresh-water genera *Astacus* and *Cambarus*, but there is good reason for supposing that it will eventually prove to be the representative of a new generic type, which at present there is not sufficient material to define satisfactorily.

Nearly the whole of the under surface of the cephalothorax of the specimen is buried in the matrix, the front margin of the carapace is very imperfect, the tail fin as well as the under part of the five abdominal segments are broken off, and only small portions of the pinching claws and of the other ambulatory legs are preserved or exposed.

The carapace is moderately convex or slightly depressed, and not quite twice as long as broad. It is divided into two nearly equal parts by a single, well marked and deeply impressed neck furrow, which is

arched forward in a shallowly concave curve. Behind this furrow the lateral margins of the carapace are slightly expanded, the test in the branchial region is moderately inflated, and the posterior margin is shallowly concave in the middle. A short distance in advance of the neck furrow, on the outer and lower portion of the carapace, on each side, there is a very short and transverse groove or narrow constriction, which may possibly be confluent with the neck furrow on the strongly inflected lateral margins of this part of the carapace. The exact outline of the anterior margin of the carapace cannot be ascertained, and the tip of the rostrum is broken off. The basal portion which remains is about seven or eight millimetres long. At the base it measures five mm. in breadth, and at the broken anterior extremity its breadth is two mm. Its outer margins are defined by two linear and acute, tuberculated and raised longitudinal ridges, between which the surface is smooth and concavely excavated.

The whole of the outer surface of the carapace is ornamented by rather distant, isolated tubercles. In its posterior moiety these tubercles are somewhat irregularly disposed, though there is a low, very narrow, and rather inconspicuous keel on the median line, on either side of which the cardiac region is comparatively smooth. On the anterior portion of the carapace the tubercles are grouped somewhat obscurely in two or three longitudinal rows on both sides of the narrow median keel, which is continued with greater or less distinctness up to the commencement of the rostrum.

The anterior pinching claws appear to have been unusually short and robust, while their surface is distinctly tuberculated. The portions of the posterior ambulatory legs that happen to be preserved, on the other hand, are very slender, and their surface is minutely granulated. The abdominal segments are badly preserved, but their outer surface seems to have been smooth, though a narrow median keel can be traced throughout the greater part of their dorsal surface.

Sounding Creek, township 30, range 8, west of the 4th Principal Meridian, 1886.

At the same locality and date five detached pinching claws of an apparently second species of decapod were collected in as many concretionary nodules. These claws resemble those of *P. ornatus* in the comparative shortness and robustness of their terminal segments, but the outer surface of the latter is finely granulated rather than coarsely tuberculated.

FISHES.

A well preserved tooth of a Selachian was collected on the Battle River, in township 46, range 3, west of the 4th Principal Meridian, in 1885; and a pectoral fin, apparently of a large selachian, at Sounding Creek, township 30, range 8, west of the 4th Principal Meridian, in 1886.

(B.) LARAMIE SPECIES.

LAMELLIBRANCHIATA.

UNIO DANÆ, Meek and Hayden.

Unio Danæ, Meek and Hayden. 1857. Proc. Ac. Nat. Sc. Phil., vol. IX, p. 145.
" " Meek. 1876. U. S. Geol. Surv. Terr., vol. IX, p. 517, pl. 41, figs. 13, a, b, c.

Bow River, opposite mouth of Fish Creek, 1886: a few very badly preserved specimens.

SPHÆRIUM FORMOSUM? Meek and Hayden, Var.

Sphærium formosum? Meek and Hayden, var. Whiteaves. 1885. Contr. to Canad. Palæont., vol. I, p. 61, pl. 9, fig. 3.

Blind Man River, township 40, range 1, west of the 5th Principal Meridian: two or three detached single valves.

As pointed out in the memoir cited, "it is doubtful whether this *Sphærium* should be regarded as merely a local variety of the *S. formosum*, or as a distinct species."

GASTEROPODA.

LIMNÆA TENUICOSTATA, Meek and Hayden.

Limnæa tenuicostata, Meek and Hayden. 1856. Proc. Ac. Nat. Sc. Phil., p. 119.
Limnæa (Acella) tenuicostata, Meek and Hayden. 1860. Ib., p. 431.
Limnæa (Pleurolimnæa) tenuicostata, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 534, pl. 44, figs. 13, a, b, c.

Blind Man River, township 40, range 1, west of the 5th Principal Meridian, 1885; a few specimens of what appears to be an unusually

fine-ribbed variety of this species, in which there are from eighteen to twenty ribs on the outer whorl, instead of from eight to twelve as in the typical form.

PHYSA COPEI, White, var. CANADENSIS.

Physa Copei, var. *Canadensis*, Whiteaves. 1885. Contr. to Canad. Palæont., vol. I., p. 14, pl. 2, figs. 5, 5 a and 5 b.

Blind Man River, township 40, range 1, west of the 5th Principal Meridian, 1885; one crushed specimen: also Bow River, section 32, township 22, range 29, west of the 4th Principal Meridian, 1885: a fragment which probably belongs to this species.

BULIMULUS (THAUMASTUS) LIMNÆIFORMIS, Meek and Hayden.

Bulimus limnæiformis, Meek and Hayden. 1856. Proc. Ac. Nat. Sc. Phil., vol. VIII., p. 118.
Thaumastus limnæiformis, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 553, pl. 44, figs. 8, a, b, c, d.
" " Whiteaves. 1885. Contr. to Canad. Palæont., vol. I., pp. 20, 27 and 72, pl. 3, fig. 3.

Bow River, section 32, township 22, range 29, west of the 4th Principal Meridian, 1885: abundant.

On the Red Deer River (in township 39, range 27, west of the 4th Principal Meridian), a fragment of a slender, reversed land shell, which appears to be congeneric with the *Columna teres* and *C. vermicula* of Meek and Hayden, was collected in 1885. The specimen consists of a natural mould of the exterior of one side of the shell, with portions of the test adherent thereto. In general outline, as well as in the amount of obliquity in its suture, it resembles *C. vermicula* more than *C. teres*, but differs from both in having only eight volutions at most, instead of twelve or thirteen.

GONIOBASIS TENUICARINATA, Meek and Hayden.

Melania tenuicarinata, Meek and Hayden. 1857. Proc. Ac. Nat. Sc. Phil., vol. IX., p. 137.
Goniobasis tenuicarinata, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 566, pl. 43, figs. 14, a, b, c.
" " Whiteaves, 1885. Contr. to Canad. Palæont., vol. I., pp. 22 and 27, pl. 3, figs. 5 and 5 a.

Red Deer River, township 39, range 27, west of the 4th Principal Meridian, 1885; and Blind Man River, Crossing of Rocky Mountain House trail, in Township 40, Range 1, west of the 5th Principal Meridian: a single specimen from each of these localities.

VIVIPARUS LEAI, Meek and Hayden.

Paludina Leai, Meek and Hayden. 1856. Proc. Ac. Nat. Sc. Phil., vol. VIII., p. 121.
Vivipara Leai, Meek & Hayden. 1860. Ib., vol. XII., p. 185.
Viviparus Leai, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 577, pl. 44, figs. 6, a, b, c, d.
Viviparus Leai, Meek and Hayden. White. 1883. Rev. Non-Marine Foss. Moll. N. Am., p. 61, pl. 27, figs. 10-14.

Blind Man River, Crossing of Rocky Mountain House trail, in township 40, range 1, west of the 5th Principal Meridian, 1886: a few well preserved and typical specimens.

VIVIPARUS TROCHIFORMIS, Meek and Hayden, Var.

Paludina trochiformis, Meek and Hayden. 1856. Proc. Ac. Nat. Sc., Phil., vol. VIII., p. 122.
Vivipara trochiformis, Meek and Hayden. 1860. Ib., vol. XII., p. 185.
Viviparus trochiformis, Meek. 1876. Rep. U. S. Geol. Surv. Terr., vol. IX., p. 580, pl. 44, figs. 2, a-e; also, White, 1883, Rev. Non-Mar. Foss. Moll. N. Am., p. 61, pl. 24, figs. 10-16.

Bow River, section 32, township 22, range 29, west of the 4th Principal Meridian, 1885: twelve specimens.

These represent a variety in which the two spiral ridges which are usually characteristic of the species are entirely obsolete, and the minute spiral revolving lines are almost completely undeveloped.

CAMPELOMA MULTILINEATA, Meek and Hayden.

Paludina multilineata, Meek and Hayden. 1856. Proc. Ac. Nat. Sc., Phil., vol. VIII., p. 120.
Vivipara multilineata, Meek and Hayden. 1860. Ib., vol. XII, p. 85.
Campeloma multilineata, Meek. 1876. Rep. U. S, Geol. Surv. Terr., vol. IX., p. 586, pl. 44, figs. 1 a, b.
" " White (as of M. & H.) 1860. U. S. Geol. Surv., Contr. to Pal., Nos. 2-8, p. 101, pl. 28, figs. 4 a, b.
" " White. (as of M. & H.) 1883. Rev. Non-Marine Foss. Moll. N. Am., p. 63, pl. 27, figs. 1-7.

Same locality and date as the preceding species: three specimens. This shell, in the writer's judgment, is a typical *Lioplax.*

CAMPELOMA PRODUCTA, White.

Campeloma (*Lioplax*) *producta*, White. 1883. Rev. Non-Marine Foss. Moll. N. Am., p. 63, pl. 26, figs. 21–27.
Campeloma producta (White.) Whiteaves. 1885. Contr. to Canad. Palæont., vol. I., pp. 24, 28 and 77.

Same locality and date as the two preceding species; also Blind Man River, crossing of Rocky Mountain House Trail, in township 40, range 1, west of the 5th Principal Meridian, 1886: abundant at each of these localities.

Notwithstanding the difference in the generic and specific name, this species seems to be very nearly related to the *Goniobasis Nebrascensis* and *G. tenuicarinata* of Meek and Hayden.

VALVATA BICINCTA, Whiteaves.

Valvata bicincta, Whiteaves. 1885. Contr. to Canad. Palæont., vol. I., p. 25. pl. 3, figs. 8, 8 a, and 8 b.

Blind Man River, township 40, range 1, west of the 5th Principal Meridian, 1885: abundant.

VALVATA FILOSA, Whiteaves.

Valvata filosa, Whiteaves. 1855. Contr. to Canad. Palæont., vol. I., p. 25, pl. 3, figs. 7 and 7 a.

Same locality and date as for the preceding species.

[This Appendix, with illustrations of the new species, will be re-printed in Part II. of the Contributions to Canadian Palæontology, now in course of publication.—J. F. W.]

APPENDIX II.

LISTS OF LEPIDOPTERA COLLECTED BY MR. J. B. TYRRELL IN 1884 AND 1885, AND MR. D. B. DOWLING IN 1886.

BY

MR. JAMES FLETCHER.

DIURNAL, 1884, 1885.

1.	*Colias Eurytheme*, Bd., summer form *Eurytheme*, Edw.	Red Deer River, near crossing of old trail to Rocky Mountain House, June 21–July 13, 1885.
2.	" " tetramorphic form *Eriphyle*, Edw.	
3.	" *Occidentalis*, Scud	
4.	" *Christina*, Edw	
5.	*Argynnis Cybele*, Fab	
6.	" *Lais*, Edw	
7.	" *Clio*, Edw	
8.	" *Triclaris*, Hub	
9.	*Phyciodes Carlotta*, Reak	Red Deer River, near the mouth of Rosebud Creek, June 13 and 16, 1884.
10.	" *Tharos*, Dru., dimorphic form *Morpheus*, Fab.	Battle River, Tod's Crossing, July 19, 1885.
11.	*Vanessa Milbertii*, Godt	
12.	*Limenitis Arthemis*, Dru., dimorphic form *Lamina*, Fab	July 3, 1885.
13.	*Cœnonympha Ochracea*, Edw	Red Deer River,* June 21–July 13, 1885.
14.	*Erebia Epipsodea*, Butler	
15.	*Satyrus Charon*, Edw	Coal Creek, July 27, 1884.
16.	*Lycæna Sæpiolus*, Bd	Red Deer River,* June 21–July 13, 1885.
17.	" *Lygdamas*, Doub	

DIURNAL, 1886.

1.	*Pieris Napi*, Esper., summer form *Oleracea-Æstiva*, Harr	Near Vermilion R., July 27.

* Near crossing of old trail to Rocky Mountain House.

2.	*Colias Eurytheme*, Bd., summer form *Eurytheme*, Edw	Near Edmonton, Sept. 9.
3.	" " tetramorphic form *Eriphyle*, Edw	Near Vermilion R., July 27.
	" " "	The Three Hills, Sept. 20.
4.	" *Occidentalis*, Scud	Saddle Lake, July 29.
5.	" *Interior*, Scud	Miry Creek,* July 19.
6.	*Danais Archippus*, Fab	Bear Hill Reserve, Sept. 12.
7.	*Argynnis Cybele*, Fab	Miry Creek, July 19.
8.	" *Lais*, Edw	" " "
9.	" *Boisduvallii*, Somm	" " "
10.	" *Bellona*, Fab	" " "
11.	*Phyciodes Tharos*, Dru., summer form *Morpheus*, Fab	Saddle Lake, July 20.
12.	*Vanessa Antiopa*, L	Miry Creek, July 19.
13.	*Pyrameis Cardui*, L	Saddle Lake, July 20.
	" "	Vermilion River, Aug. 10.
14.	*Limenitis Arthemis*, Dru., dimorphic form *Lamina*, Fab	Saskatchewan, July 19.
15.	*Satyrus Alope*, Fab., dimorphic form *Nephele*, Kirby	Vermilion River, July 28.
16.	" " var. *Olympus*, Edw	" " "
17.	" " var. *Boopis*, Behr	" " "
18.	*Chrysophanus Thoe*, Bd. Lec	Miry Creek, July 19.
	" "	Vermilion River, July 28.
19.	" *Florus*, Edw	Miry Creek, July 19.

NOCTURNAL, 1886.

1.	*Sphinx Albescens*, Tepper	Bull Pound Creek, May 16.
2.	*Syneda Athabasca*, Neum	Buffalo Coulée, June 22.
3.	*Phasiane Aberrata*, H. Edw	Battle River, near Buffalo Creek, June 25.
4.	*Eufitchia Ribeata*, Fitch	Battle River, near Buffalo Creek, June 25.
5.	*Agrotis Clandestina*, Harr	Iron Creek, June 29.
6.	*Arctia Virgo*, L	Beaver Lake, July 8.
7.	*Plusia Californica*, Spey	Edmonton, July 15.
8.	*Botis Fodinalis*, Pack	Edmonton, July 15.
9.	*Metrocampa Perlaria*, Guen	Edmonton, July 15.
10.	*Acidalia nivosata*, Guen	Battle River, near Buffalo Creek, June 25.

* Ten miles east of Victoria on the trail north of the North Saskatchewan river.

APPENDIX III.

LIST OF ELEVATIONS.*

The following are the elevations of the stations on the Canadian Pacific Railway, within the limits of the accompanying map:—

	Feet above sea Level.
Cochrane	3,712
Radnor	3,825
Morley	4,032

The following are points on the old location line of the Canadian Pacific Railway, the heights of which have been instrumentaly determined, and are given in the Canadian Pacific Railway Report, 1877. They were leveled up from Lake Superior, which was taken at 596 feet above mean tide level, a height which is six feet too low. Six feet must, therefore, be added to all the heights given in this table. The positions of these points are laid down on the map with as much accuracy as the information at our disposal would permit.

	Feet above sea level.
F	2,125
G	2,101
H	2,165
Grizzly Bear	2,145
I	2,210
K	2,240
L	2,325
M	2,325
N	2,243
O	2,287
P	2,363
Q	2,473

* During the summer of 1887, Mr. Warren Upham while tracing out and levelling the beaches of the glacial lake Agassiz in Manitoba, found that the O point on the Canadian Pacific Railway just west of Winnipeg had been taken at 737 feet, instead of 759 feet, which is its true elevation above mean tide. All the elevations, therefore, from Winnipeg to the Rocky Mountains which are based on this O point are 22 feet too low. This will leave the cistern of the barometer at Calgary 3,411 feet instead of 3,389 feet, as stated above; and 22 feet must be added to all the heights given in this report, except those of the old location of the Canadian Pacific Railway. For early information on this subject, I am indebted to the kindness of Mr. Warren Upham himself.

R.	2,500
Highest point on this part of the line	2,555
S.	2,500
Edmonton	2,413
Grandin	2,380
Crossing of North Saskatchewan, 104 feet above the river	2,200
Siksika	2,320
Laplaine	2,422
Palliser	2,413
Belcour	2,407

The following are some of the elevations that were determined with a mercurial barometer compared with the standard barometers used at Calgary, Medicine Hat and Edmonton. The readings were usually taken at the same time as the readings of the standards; but when this was impossible, corrections were in every case made for the difference in time.

Compared with Calgary (3389 ft.) and Medicine Hat (2142 ft.):—

	FEET ABOVE SEA LEVEL.
Lorne Crossing, Red Deer River	2,167
Berry Creek, at Lorne trail	2,412
Sounding Creek, Lorne trail	2,449
Elbow of Sounding Creek (7 readings)	2,174
Sounding Lake	2,140
Ribstone Creek, near the western limit of range 8	2,330
Ribstone Creek, in southwest corner of township 40, Range 6	2,192
Battle River, crossing of Fort Pitt trail	1,694
Lake in Blackfoot Hills	2,249
Buffalo Creek, one mile from Battle River	1,942
Iron Creek, ten miles above its mouth	2,051

Compared with Calgary:—

Bigstone Creek,	Calgary-Edmonton trail		2,460
Battle River, Leavings	"	"	2,457
Wolf Creek	"	"	2,613
Lone Pine	"	"	3,290
Rosebud Creek,	"	"	3,232
Small lake in tp. 28	"	"	3,577
Battle Lake			2,770
Mouth of Pigeon Lake Creek			2,719
Egg Lake (near Victoria)			1,997
Blind Man River, crossing of Rocky Mountain House trail (38 readings)			2,827
Medicine River	"		2,995
Western lake of "Chain of Lakes"			1,921
Rocky Mountain House			3,153
Bear Lake			2,624

Compared with Edmonton, the height of which is taken as 2,210 feet:

Beaver Lake	2,178
Mouth of Smoky Creek	1,871
Mouth of Saddle Lake Creek	1,823
Saskatchewan River at Fort Pitt	1,722
Mouth of Brazeau River	2,637
Big Coal Seam on Saskatchewan River	2,307
Pigeon Lake	2,824
Weed Creek, crossing of Pigeon Lake trail	2,566

The following elevations were taken with aneroids during the summer of 1886, compared with the standards at the places mentioned in brackets:—

Birch Lake (Edmonton)	2,140
Cooking Lake "	2,400
Hastings Lake "	2,380
Buck Lake (Crossing of Blind Man River)	2,970
Gull Lake " " "	2,905
(Black Butte	2,190)
Red Deer River, crossing of Calgary-Edmonton trail, (Calgary and Edmonton)	2,727

The following are some of the principal elevations obtained with aneroids during the summer of 1885, compared with readings of the standard at Calgary:—

Little Red Deer River at outer edge of foot-hills	3,979
Little Red Deer River, at crossing of Rocky Mountain House trail	3,192
Fallen Timber Creek, edge of foot-hills	4,448
Fallen Timber Creek, at its mouth	3,753
Red Deer River, Stoney pack-trail	4,328
" " edge of foot-hills	3,955
" " Rocky Mountain House trail	3,172
Battle River Settlement, top of bank	2,408
Egg Lake (in Hand Hills)	2,970
Mouth of Tail Creek	2,390
Dried Meat Lake	2,230
Elbow of Battle River	2,125
Little Fish Lake	2,890
Top of Hand Hills	3,555

APPENDIX IV.

CREE AND STONEY INDIAN NAMES FOR PLACES WITHIN THE AREA OF THE ACCOMPANYING MAP.

The greater number of these names were obtained from William Kitchipwat, a Stoney Indian from the Morley reserve, who worked for me during part of the summer of 1885, and for the rest I am indebted to Mr. McKay, an educated Cree half-breed, who was in charge of the Hudson's Bay Company's post at Fort Pitt, and to James Prudens, jr., and Simon Fraser, two other Cree half-breeds.

In the majority of cases, the English name is merely a translation of the Cree, but where this is not the case, the meaning of the Indian word is printed under it in brackets. The Stoney name is also generally a translation of that used by the Crees, but when it differs, its meaning is printed under it in the same way. Where the syllables were sharply defined in pronunciation, they have been separated by a hyphen, but where they were run rapidly together, the hyphen has been omitted.

The following list of vowels and diphthongs will show the sound that each is intended to represent. The list is essentially the same as that used by Drs. Tolmie and Dawson in their "Comparative Vocabularies of the Indian Tribes of British Columbia"* :—

a	as in English		*fat.*
ā	"	"	*father.*
e	"	"	*met.*
ē	"	"	*they.*
i	"	"	*pin.*
ī	"	"	*marine.*
o	"	"	*go.*
u	"	"	*nut.*
ai	"	"	*aisle.*
oi	"	"	*join.*
oo	"	"	*pool.*
ow	"	"	*now.*

* Special Report of Geol. Survey, 1884.

INDIAN NAMES OF PLACES.

English.	Cree (Ni-hī-a-wē'.)	Stoney (As-sin-pwā-tis)
Buffalo Lake	Moos-toos Sa-kha'-hīgan	Ta-toong-gāmna
Buck "	Ya'-pē oo "	Tam-no-āmna
Gull "	Kī-as'-koos "	Pi-chat-to āmna
Snake "	Kin-a-pik' "	Mno-hemna
Swan "	Wā'-pi-sioo "	Ko-gāmna
Pigeon "	Hmī-hmoo " (Woodpecker Lake.)	Ka-ka-gāmna
James River Lakes	Jī-mis Sī-pi "	Jī-mis-wap tim'ni
Devil's Lake (in Rocky Mountains.)	Ki-no-ka-mak' " (Long Lake.)	Mnith-to
Dead Wood Lake (between Clearwater R. and Prairie Creek).		Che-shem'na
Wood Lake		Cha-gam'na
Hollow "		Mi-hi-dwā
Muskeg "		Tāsāk-tem'na
Egg "	Ma-na-wān Sa-kha'-hīgan	
Sounding "	Ni-pik-ap-hit-i-kwek (Sounding water.)	
Saddle "	O-nis-chik-hskop'-uwin Sa-kha'-hīgan	
Frog "	Ah-yik Sa-kha'-hīgan	
Onion "	Wis-chēk-oos-o-sioo "	
Stony "	Sin-is-kow' "	
Fishing "	Pu-ka-che-wān' " (Little fishing place.)	
Crooked "	Wā-wā-ka'-tin-ow "	
Lake St. Ann	Ma-ni-to " (Spirit Lake.)	
Lac la Nonne	Mi-ka-sioo " (Eagle Lake.)	
Big Lake	Mis-ta he "	
Dried Meat Lake	Kā-ke-wuk' "	
Sullivan "	Ka-ki-no-ka-mak' " (Long Lake.)	
Dry Grass "	Pa-kwas-kow "	
Hay "	A-pī'-chī-koo-chī-wās' (Little swamp.)	
Bear "	Mus-kwa chi Sa-kha'-hīgan. (Bear Hills Lake.)	
Bittern "	Mo-kā'-kā-sioo "	
Beaver "	A-misk-wā-chi " (Beaver Hills Lake.)	
Rolling Hills Lake (east of Hay L. trail)	Pi-ti-koo-ka-mow' "	
White Wood Lake	Wa-pi-ta-kow' "	
A N. and S. chain of lakes in the hills, 15 miles S. W. of Beaver Lake.		
Flat Lake	Ka-ta-ta-kwa-cha-o-ka-mak	

INDIAN NAMES OF PLACES—*Continued.*

English.	Cree (Ni-hī-a-wē'.)	Stoney (As-sin-pwā-tis)
Two lakes east of Flat Lake	Sī-wī-tā'gan Sa-kha'-hī-gana. (Salt Lakes.)	
Dusty Lake	Ko-pwa-o-wa-gas-takh	
Island "	Ka-min-ta'-gu-sikh	
Birch "	Wās'-kwa-ī Sa-kha'-hīgan	
Cooking "	O-pi mi-now'-wa-sioo "	
Hastings "	A-ka-ka'-kwa-tikh (The lake that does not freeze.)	
Red Deer River	Wās'-ka-sioo Sī-pī	Pa-chī-dī-wāp-ta
Little Red Deer River	Was-kē'-sis Sī-pī'-sis	" wāp-tan
Ghost River	Chi'-pē-ī Sī-pī	Win-chin-a-i-wāp-ta
Fallen Timber Creek	Kow-ikh-ti-kow' Sī-pī'-sis	O-ta-ha-wāp-ta
Bearberry Creek	A-chuk-i-sī'-pī "	A-be-wāp-tan
James River	Jī-mis Sī-pī	Jī-mis-tumb-wāp-ta
Dog Pound Creek	Ko-ma-tas'-ta-moin Sī-pī'-sis (Stolen Horse (or Dog) Creek.)	So-mun-ib- "
Clearwater River	Wā-sē'-ga-mow Sī-pī	Mnith-ow'- "
Blind Man "	Pas-ka-poo "	Is-tap-ta- " or Cham-bath-na-dab-wāp-ta (Dead standing-timber River.)
Bow "	Ma-na-chā'-ban "	Mi-nith-ni (Cold River.)
Raven "	Ka-ka-koo' "	Kaı'-him-bu-wāp-ta
Medicine "	Mās-kī'-kīoo " / Ni-pa-gwā'-si-mow " (Sun dance River.)	To-go-wāp-ta (Mussel River.)
Horse Pound Creek	Ka-ni-wās'-ta-moin Sī-pī'-sis (Horse-guard Creek.)	Soon-kowīng-wuab-wāp-ta
Battle River	No-tin'-to Sī-pī	Ke'-chi-sab-wāp-ta
Open Creek (The creek that does not freeze)	As-kow-ī Sī pī'-sis	So'-men-ib- "
Muskrat Cr. (flows into Prairie Cr. from N.)	Wa-cha'sk "	Hthump-to-dab-wāp-ta
Pigeon Lake Creek	Hmī hmoo Sa-kha'-higan Sī-pī'-sis (Woodpecker lake Creek.)	Ke-gemni-wāp-ta
Elbow River	O-toos-kwa-na' Sī-pī'-sis	Nm-no-tho-āp-ta
Wolf Creek	Mu-hī-khan' "	Sik-to-do- "
Smoky River	Kas-ka'-pi-tē Sī-pī	Swo-da- "
Brazeau "		Tum-wāp-ta
Prairie Creek	Mas-kioo-tē'-oo "	Tin-dow-wāp-ta
Saskatchewan	Kis-is-ska-tche-wan (Rapid river.)	Wāp-tam-notha
Grease Creek	To'-muna Sī-pī'-sis	Sna-tin-da-wāp-ta
Tail "	O-soo-ī' "	Sin-doo- "
Rosebud "	Mis-sas-ka-too'-mina Sī-pī'-sis (Service Berry Creek.)	Mī-tha'ga-wāp-tan
Nose "	Os-kewun' "	Tap-o-oi-wāp-ta

INDIAN NAMES OF PLACES—*Continued.*

ENGLISH.	CREE (Ni-hī-a-wē'.)	STONEY (As-sin-pwā-tis)
Jumping Pound Creek...	....	To-ko-jap-tab-wāp-ta
Egg " ...	Man-a-wān Sī pī'-sis....	
White Earth " ...	Wā-pī-tan-isk' "	
Pipestone " ...	Man-is-pwā'-ga-nan " .... (The creek where pipes are got.)	
Frog " ...	Ah-yik-i "	
Moose " ...	Moos-wa-chī'-wī " .... (Moose Hill Creek.)	
Dog " ...	A-tim O-soo-ī-kun' " .... (Dog Rump Creek.)	
Vermilion River........	Wē-i-mun' Sī-pī..............	
Conjuring Creek.........	Pāw-ga-mow Sī-pī'-sis............ (Vomiting Creek.) or Mi-tē-oo "	
Strawberry "	A-te-min "	
Creek that does not freeze (in Beaver Hills.)...	A-ka-ka'-kwa-tikh "	
Halfway Creek.........	A-pi-tow "	
Cache "	As-tākh'-si-kun "	
Weed "	At-che-kas-puk "	
Hay "	Mas-kioo-si-kan "	
Crooked "	Wā-wā-ka'-tin-ow "	
Grizzly Bear Creek.....	Mist-ā-yā "	
Ribstone "	As-sin-i-kos-pi-kē-gan-it	
Iron "	Pī-wa-pisk-oo Sī-pī'-sis..........	
Meeting "	Nukh-kwa-ta-to "	
Stony "	Ka-as-sin-is-kak "	
Sturgeon River.........	Mi-koo-oo-pow Sī-pī.............. (Red Willow Creek.)	
Rivière qui Barre......	Ma-ta-hi-to Sī-pī'-sis.............. (Present Creek.)	
Hastings Creek..........	Kak-sī'-chī-wukh' .... (Swift Current.)	
Deep "	Ka-ta-mikh Sī-pī'-sis.............	
Beaver "	A-misk-wā-chī-oo "	
Black Mud "	Kas-ki-tē'-oo as-is-ki. "	
Rocky Mountains........	As-sin-wāti	Ni-a'-ha
Devil's Head Mtn......	Wē-ti-kwos'-ti-kwan.................	Si-ham'-pa
Eagle Hill...............	Ki-hi-a-wātis	Mha-moos-ni-bin
Hat Mountain (near source of Clear-water River).........	As'-tu-tin As-sin-wāti	Ni-a-he-tis na-ki-ta-wan
Hand Hills..............	Mī-chī-chī Is-pa-tin-an.............	O-chun-um-bin
Three "	Nis-to "	Pa-ha-am-ni
Knee "	Mi-chig-wun "	Che-swun-de-ba-ha
Antler Hill.............	Wās-ka-suk is-kun ka-so-pit......... (The pile of Elk horns.)	Pa-chi-di ha-ba jo-bi
Beaver Hills............	A-misk-wā-chi..........................	Cha-ba-hē-ī
Bear "	Mus-kwā-chī-si	O-zin-za-hen

INDIAN NAMES OF PLACES.—*Continued.*

ENGLISH.	CREE (Ni-hī-a-wē'.)	STONEY (As-sin-pwā-tis)
Castle Mountain	O-mask-wē-oo As-sin-wā ti (Queen Mountain.)	
Swampy Hill (east of Raven River)	Mus-keg-wāti	Wa-ku-ni-a-ha
Hill east of Little Red Deer River		Chow-o-bo-o-zin am- [ba-ha
Little Hill		Ba-how-oo-dan
Blackfoot Hills	Ah-as-thī-nioo-wā-chi.	
Two Big "	Nis-wa kis-pa-tin-ak	
Frenchman's Butte	We-mis-ti-koo-shē-we-cha-ka-tin-ow	
Moose Hills	Moos-wa-chi	
Nose Hill	Os-ke-wun-ā-chio	
Cypress Hills	Mi-na-ti-kak *or* Ne-a-ti-kak	Pa-ha-toonga
Little Beaver Hills	Pikh-tow A-misk-wā-chi	
Pretty Hill	Ka-mī-wa-sit Is-pa-tin-ow	
Peace Hills	Wī-ta-ski-oo Cha-ka-tin-ow	
Rocky Mtn. House	Kai-as As-sin-wāti Was-kā'-hīgan	Tī-shī-a
Calgary	O-toos-kwa-nik " (Elbow House.)	
Edmonton	A-misk-wā chi " (Beaver Hills House.)	Ti-tung-a
Fort Saskatchewan	Sī-mā'-gan-is " (Soldiers House.)	
Fort Pitt	Was-kā-ha-gan-is (The Little House.)	

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

PRELIMINARY REPORT

ON

AN EXPLORATION OF COUNTRY

BETWEEN

LAKE WINNIPEG AND HUDSON BAY.

BY

A. P. LOW, B.Ap.Sc.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1887.

To ALFRED R. C. SELWYN, ESQ., C.M.G., F.R.S., LL.D.,

Director Geological and Natural History Survey of Canada.

SIR,—I herewith beg to submit a Preliminary Report on my explorations of last season in the country between Lake Winnipeg and Hudson Bay.

In it I have merely mentioned the geological formations observed along the route followed. To define their probable distribution in the region, one or more seasons work will be required. I have great pleasure in tendering thanks to J. Wrigley, Esq., Chief Commissioner of the Hudson Bay Company, and all the officers of the Company, at the posts visited, for their kind hospitality and able assistance, to which, in a great measure, the success of the expedition is due.

I remain,

Sir,

Your obedient servant,

A. P. LOW.

OTTAWA, February 24th, 1887.

PRELIMINARY REPORT

ON AN EXPLORATION OF COUNTRY FROM

LAKE WINNIPEG TO HUDSON BAY,

BETWEEN 88° 30′ AND 97° 30′ W. LONG.

I left Ottawa on the 10th of May, accompanied by Mr. J. M. Macoun as assistant and botanist. We proceeded to West Selkirk, in Manitoba, where we were detained eight days, awaiting the departure of a vessel which could take us up Lake Winnipeg. Departure.

We then secured passages in a small schooner, which sailed on the 21st of May, but which, owing to head winds, did not reach our starting point—the mouth of Berens River, half way up the lake on its eastern side—till the 28th of May.

The spring was exceptionally early, and the ice had, we were told, broken up fully a week earlier than usual.

At the Hudson Bay post, Mr. Flett informed us that large canoes, suitable for our expedition, could only be obtained at the Company's post on Family Lake, some distance up the river. We therefore purchased two small canoes in which to take a part of our provisions and outfit, and we engaged Indians, with three canoes, to take the rest up to Family Lake. All necessary arrangements having been completed, we left the mouth of the river late on the morning of the 31st, and the micrometer survey was carried as far as the first portage, eleven and a half miles. Commencement of Survey

The country near the river in this distance is made up of many low, hummocky, gneiss hills, which seldom rise twenty feet above the water, and are partly covered with a heavy clay soil. In the valleys and along the river banks the soil is thicker, and the Hudson Bay Company, and the Indians on the Reserve, grow good crops of potatoes and other roots. Little or no grain is raised, and the locality seems unfavorable for such crops, being exposed to the full sweep of the cold north-west winds that blow so frequently over Lake Winnipeg. The tree growth is small and poor, consisting of black spruce, aspen poplar, tamarac, white birch, banksian pine and balsam. None of

these attain a diameter of eighteen inches, and, branching near the ground, are mostly covered with knots and crooked, and of little value for lumber.

Up to the first portage, the river flows between rocky banks from ten to twenty feet high, alternating with low, swampy ground. The current is sluggish, the water deep and of a dark brown color, although comparatively free from suspended matter.

The Indian Reserve extends six miles up the river, its banks being dotted with log houses. The Methodist mission station consists of a good church, school house and parsonage.

Sturgeon are plentiful in the spring about the mouth of the river, and up it as far as the first fall.

On the 1st of June we did not leave camp, on account of rain, until 11 a.m., and we then made a portage of forty yards to pass a chute of nine feet, caused by a ledge of gneiss in the river. Three hundred yards further, another portage of twenty yards was made to pass a similar fall of three feet. From this point up to Family Lake the river's course is broken by a great number of small chutes, varying from two to forty feet in height, and all have to be passed by short portages; between the chutes there is little or no current in the river, and it somewhat resembles the locks and stretches of a canal. During the day six other chutes were passed, being respectively four, three, five, ten, and three feet high, with portages of fifty, thirty, eighty, forty and thirty yards, and the total distance surveyed was nine and one-quarter miles. In this distance the banks are less rocky, with more good land and heavier timber. Some white spruce being eighteen inches in diameter, with poplar and banksian pine of twelve to fifteen inches.

Character of Berens River.

From the second to the fifth of June, we continued our ascent of the river, and passed twenty-seven falls and rapids, entailing as many short portages in a distance of fifty-one miles, the country being rocky, with poor soil and small trees. Here the route leaves the river and crosses a short portage to a small branch, which it follows for four and a half miles to where it re-joins the river at a small lake, and thus a very rapid and difficult stretch of the main river is avoided. A fall of six feet connects this lake with another, passing through which, a distance of four miles, the river is again reached. From here to the outlet of Family Lake the distance is eleven miles. Three portages occur in the interval to pass falls of eight, ten and forty feet, the last and highest being just at the outlet of the lake. Family Lake is triangular in shape, having irregular sides of about ten miles in length. The river comes in at the north-east angle, where also is the Hudson Bay Company's post. It is proposed to survey a

Family Lake.

reserve in the vicinity for the Indians who trade at the post. Two streams flow out of the lake, the Berens River at the western angle and the Pigeon River at the southern. These streams, after following irregularly parallel courses, enter Lake Winnipeg only six miles apart. Considerable areas of good land occur along the shores of the lake, although they are often very rocky.

The trees are somewhat larger than those along the river, and at the Hudson Bay Company's post good crops of potatoes are grown.

The total length of our measured line from Lake Winnipeg to the inlet is one hundred and two miles, with a general course of S. 7° E. The greater part of the timber has been destroyed by frequent fires. On the 9th of June, having exchanged our small canoes for larger ones at the Hudson Bay post, and engaged two Indians to take a load of provisions as far as Deer Lake, on the Severn River, we continued our ascent of the Berens River. A fall and rapid of thirty-five feet, passed by a portage one-quarter of a mile long, occurs one mile from the lake. Above this the river is deep and rapid for one mile, when it widens into Back or Fishing Lake. This lake is nine miles long from north to south, and from two to four miles wide, with a large number of islands along the eastern side. A large stream, called the Mattawa River, which rises in the neighborhood of Cat Lake, enters on the east side. The lake is surrounded by hills, rising twenty to forty feet above its level; these are covered with a growth of spruce, poplar, birch and tamarac, much of which has, however, been burnt by recent fires. Ascending between the islands, we left the lake at its northern end by a small stream, which flows in a very crooked course through low, swampy ground, with protruding bosses of gneiss, the whole covered with a small growth of black spruce and tamarac. After following this stream four miles, Fisher Lake was reached and traversed, a distance of three miles, to its upper end; thence the river was again followed, through four small unnamed lakes, to the height of land between the Poplar and Berens rivers. The country along the route, with the exception of some patches of bog, is rocky, with very little soil. The trees do not exceed eight inches in diameter, and are chiefly banksian pine, black spruce and tamarac, with some birch and poplar. Crossing the height of land by a portage two hundred yards long, the route followed a branch of the Poplar River, passing through three small lakes to Big Jack-fish Lake, a large body of water on the main branch of the Poplar River. After ascending the river seven miles, in an easterly direction, a small northern branch was followed, leading, in a crooked course, through three small lakes, to the height of land dividing the waters flowing directly into Hudson Bay from those falling into Lake Winnipeg. This point was

Grand rapid.

Poor land.

Small timber.

not reached till the 17th of June, much delay having been occasioned by the low state of the water in the small streams; four days were also lost on account of rain, it being impossible to carry on a micrometer survey in wet weather. The distance from Family Lake to this height of land is sixty-six and a half miles by the route followed, the course being a few degrees east of north.

Height of land portage.

The height of land portage, six hundred and seventy-five yards long, passes through a gulley between hills from fifty to seventy-five feet high, and ends on the north side at a small lake on the headwaters of the middle branch of the Severn River. This lake lies about fifty feet below that at the other end of the portage, and shows that the land on the north side falls abruptly. The dividing ridge stretches away in a south-easterly direction, rising from fifty to one hundred and fifty feet above the water surface.

Head of Severn River.

The first lake or pond, one-quarter of a mile long, empties into a second by a brook too small and shallow to float canoes, so that a portage of thirty-five yards has to be made between the lakes. The second lake, three-quarters of a mile in length, empties into Black Birch Lake by a brook, having six feet fall; passed by making a portage one hundred and ten yards long.

Burnt timber.

We reached Black Birch Lake about its middle, and then coasted its shores in an easterly direction for three miles to its outlet. The shores rise from thirty to fifty feet almost perpendicularly above the lake; the trees are larger than those last described, but nearly seven-eighths of the timber has been burnt. Turning north down the outlet, the stream, varying in width from ten yards at the falls and rapids to half a mile, was followed ten miles to Deer Lake through a rough, barren and rocky country, almost wholly burnt; chutes of twelve, eight and six feet were passed in this distance, and the entrance of Deer Lake was reached on the 18th of June. Here, on a small island, we found the provisions forwarded from Family Lake, safely stored.

Deer Lake.

Having transferred them to our canoes, we continued the survey along the north side of the lake, for nine miles, to the supposed outlet, which, however, proved to be an inflowing stream. As we were without a guide, we were obliged to coast carefully along the shore and around each small bay. Thus the north shore of the lake was surveyed to its extreme end, where, at a distance of forty miles from the supposed outlet, another large stream was found flowing in. Knowing that the chances were greatly in favor of the outlet being on the north side, and thinking that it might have been passed, we carefully retraced the coast for twelve miles, and succeeded in finding the outlet in a small bay. It passed through a narrow cleft in a high rock, and was not visible, even when close to its entrance. Deer Lake is a long, narrow

body of water, surrounded by rocky hills, rising from fifty to two hundred feet above the lake. These hills are rounded, and appear to run parallel to the range forming the height of land. The lake runs in a general course of N. 7° E. Its greatest length is about forty-five miles, with a breadth varying from one to four miles. Three deep bays indent its eastern end, the entrances into which are narrow and easily overlooked, unless the shore is very closely followed. The outlet is in the north bay, four miles from its entrance. Besides the bays above mentioned, several large and many smaller lateral bays deeply indent the shores, which are generally steep and rocky, and the lake itself is full of rocky islands rising from its clear waters. The surrounding hills have been almost wholly burnt by fires of various dates, and present all the different appearances of a burnt country, from the standing blackened trunks left by recent burning, to the small second growth of poplar and banksian pine of earlier fires. The soil is very thin and the timber correspondingly poor, except on a few low points, where some white spruce, balsam and poplar exceed fifteen inches in diameter. The river runs in a northerly direction, with a swift current, for one mile, and then expands into a small lake, one mile beyond which it turns sharply to the west and contracts, flowing with a rapid current for five miles between high, rocky banks covered only with dry moss and a few stunted black spruce, birch and banksian pine, all less than four inches in diameter. In this distance there are five chutes, which together give forty-nine feet fall; or sixteen, ten, six, five and twelve feet. Here the river again turns north, and, spreading out, flows with a steady current for eighteen miles to Favorable Lake, but interrupted by chutes of three, twenty and twelve feet and a few small rapids. As the river descends, the surrounding country gradually becomes smoother and the timber larger until within three miles of the lake, when the stream passes through low, swampy land, covered with thick, wet moss and a small growth of black spruce and tamarac. We entered the lake at its south-west corner, and followed the north shore for nine and a half miles to the end of a point; here the lake took a short turn to the northward, and again stretched out east and west. Supposing the outlet to be to the eastward, we surveyed to the end of the lake in that direction, seven and a quarter miles, and found two small streams flowing in. Returning to the point, we proceeded westward six miles to a small channel from the north, and discovered that the point was the end of a peninsula about seven miles long, joined to the main shore by a narrow neck of sand, over which a small portage might have been made and fifteen miles of paddling avoided. After passing through this channel one mile, the lake again expanded, and we then followed the west shore nine miles,

Deep bays.

Some good soil.

Rapid fall of river.

Favorable Lake

and found the outlet in the north-west angle, where two bays were seen stretching away to the eastward. Favorable Lake is very irregular in shape, the two portions forming a T, the stem of which lies north and south, with a crooked head stretching irregularly east and west. The width varies from two to five miles. Hills from fifty to one hundred and fifty feet high surround the lake, more than half the timber on which has been burnt. Along the shores there are considerable areas of good land, the best being on the peninsula and along the southern part of the lake, where the underlying rocks are hornblendic and chloritic schists; the northern portion is more barren, the soil resting on gneiss. The soil is a fine, rich, sandy loam, quite suitable for growing good crops, and summer frosts seem to be the only drawback to successful agriculture. These are said not to occur at Trout Lake, though situated further to the north-eastward. The trees around Favorable Lake consist of white and black spruce, aspen and balsam poplar, white birch, balsam and tamarac, many of which exceed eighteen inches in diamater. Sturgeon are plentiful in the lake; it is remarkably free from islands; the water is a dirty light yellow color, and not deep. At the end of the peninsula the foundations of several old houses were discovered, out of which trees twelve inches in diameter were growing. These ruins evidently mark the site of some old Hudson Bay Company, or more probably North-west Company trading post. Nothing was known about it at the Hudson Bay Company's post we visited. Favorable Lake was left on the 29th of June, and at two miles due north a fall of eight feet was reached; this fall is formed by a horizontal ledge of gneiss, which closely resembles a mill-dam. Three-quarters of a mile further on, a portage of seventy-five yards was made to pass a chute of twenty-five feet. Beyond this, the river flows in the same northerly course seven miles, when another chute of fifteen feet was reached.

Good soil and timber.

Old trading post.

From here the stream bends gradually westward for ten miles, then turns sharply north for five miles, and again bends slightly north of east for ten and a half miles. Here the river apparently forked; thinking that the north branch, which looked the larger, the correct road, we passed up it and entered a lake, only to find, after making a survey of its shore, that we were once more at the place we entered by, that no other outlet existed, and that we had gone ten miles out of our way. Continuing down the river seven miles due east, a sharp turn to the south was made, and passing four and a half miles along this course, Musk-rat Dam Lake was entered.

Slow current.

For the entire distance between Favorable Lake and this lake, the river, with the exception of the three falls mentioned, flows with an imperceptible current between low, muddy banks, covered along the

edges with grass and weeds, and has an average breadth of two hun-hundred feet. The water is of a whitish-yellow color, and is highly charged with suspended matter.

Swamps. The surrounding country is a vast, level swamp, broken only by a few knobs of gneiss, that rise from ten to fifty feet above the general surface. The swamp is covered with moss, and supports a small growth of black spruce and tamarac; better timber growing on and around the hills. Musk-rat Dam Lake was entered July 3rd, on its north side, some distaece from the west end. Owing to the smoky state of the atmosphere, and the numerous islands which obstruct the view, neither the west end nor the south shore were seen, and so the exact size of the lake is unknown. We coasted along the north shore to the south-eastern angle, a distance of nineteen and a half miles, passing many islands of various sizes. Where the river enters the lake, it has deposited much of the matter it carries, and formed a long point of low marsh, now covered with grasses and small willows, Long points. and surrounding several small, rocky islands; the name of the lake is probably due to this feature. Elsewhere, the shore rises from thirty to seventy-five feet above the water, the greater part consisting of clay and loam soil with several rocky points and outlying islands. The Good land. timber, with the exception of that growing on the points and islands, corresponds in size and variety to that described around Favorable Lake. The islands, many of which are quite large, are rocky, and covered chiefly with a dense growth of black spruce. Several extensive fires were burning around the lake while we were on it, and the Fires. smoke was so thick that it caused considerable delay in the work of surveying. We left Musk-rat Dam Lake at its south-east angle, and followed the river in a S. 30° E. course for four miles to Sandy Lake.

Sandy Lake. This lake was also entered on its north side at some distance from the western end, and the shore followed to the eastern extremity, a distance of forty-three and a half miles. This is probably the largest body of water passed through on the route, its extreme length and breadth being unknown, as the surface is covered by innumerable islands, so close together that a view of the opposite shore could not be had.

High rocky shores. The water is turbid and white in color. The shore is higher and more rocky than that of Musk-rat Dam Lake, but much good land, and many trees of white spruce, poplar, birch and balsam, were seen, exceeding eighteen inches in diameter. Indeed, the greater part of the land around these lakes would make good farms.

Severn Lake lies north-east of Sandy Lake, and distant from it one hundred and fourteen miles by the river. Sandy Lake was left on the 8th of July. The river passes with a sluggish current between low

hills, mostly burnt; and at six and three-quarter miles, a chute of eighteen feet was passed by a portage one hundred and fifty yards long. Beyond this, the river becomes narrow and crooked, with a swift current, passing low, rounded and rather rocky hills, with good soil between, supporting a growth of black and white spruce, tamarac, poplar and birch, slightly smaller than those seen around the lakes.

River narrow and crooked.

Forty-two miles from the portage, the river widens out into two lakes, which, together, are sixteen miles long and not above two miles broad, both being dotted with many small islands. The surrounding country is almost flat, with good timber and soil. Beyond this, as far as Severn Lake, over 114 miles north-east from Sandy Lake, the river flows with a swift current, broken by several rapids and falls, entailing six portages.

Flat country.

Cut banks.

Cut banks, from five to ten feet high, composed chiefly of a boulder-clay, are now seen. The soil and timber become poorer, and good trees grow only on the islands. the shore having a thick growth of black spruce, poplar and tamarac of small size.

While camped on the last portage above Severn Lake, an old Indian with his wife passed in a canoe, the first persons seen since leaving Family Lake. As we had but an imperfect idea of our exact position, we hurried after and overtook them on an island in the lake, and learnt that we were on Severn Lake, and that, by a portage route, the Hudson Bay Company's post on Trout Lake was distant about three days' journey. As our provisions were running short, not enough remaining to carry the survey to the mouth of the river, we decided to make for Trout Lake. Accordingly, we crossed the lake in a south-east direction, and in nine miles reached the portage.

Severn Lake.

The shores and the numerous islands of Severn Lake are all low and swampy, covered chiefly with black spruce and tamarac. The portage by which the height of land between the Main and Fawn branches of the Severn River is passed, is one and a quarter miles long, through low, swampy ground, with a rocky ridge at the east end. Here a small lake and another portage of 400 yards brought us to three small lakes, connected by a small stream; leaving the stream at the third lake, three portages of 350, 760 and 375 yards, are passed with two intervening small lakes, the stream being again reached at the end of the third portage. Descending it two and a half miles, Little Trout Lake, four miles long by one broad, was entered and passed through to its east end. Following its outlet four miles, Trout Lake was reached July 19th. The general course of the route was due east, through low, swampy country, out of which rise a few low, rocky hills almost destitute of soil, the whole covered with small trees of black spruce, banksian pine and tamarac, few exceeding six inches in

Portage route to Trout Lake.

Low swampy country.

diameter two feet from the ground. Trout Lake is irregularly oval in shape, forty miles long from east to west, and nowhere more than twenty miles wide. Its shores are generally low and swampy, with some rocky points, the highest land being towards the west and south. Along the north side are several large islands and numerous smaller, rocky ones. The prevailing trees are black spruce, with tamarac, aspen poplar, white spruce and birch, a few being eighteen inches in diameter. **Large islands.**

The water of the lake is remarkably clear, cold and deep, and is abundantly stocked with large white fish and lake trout, which form the principal food of the Indians and Hudson Bay Company's people living around the lake. **Fish.**

The Hudson Bay Company's post is situated on one of the larger islands, twelve miles from the east end. Here also is a church, supported by the Church Missionary Society of England, and the services are conducted by a native missionary. **Church.**

Nearly 500 Indians trade at this post, but they do not all belong to the post, part being a roaming population, some of whom belong to Martin's Falls and Cat Lake posts, on the Albany River, while others come from York, Severn and Island Lake. These Indians speak a language made up chiefly of Cree words, with a mixture of the Sautaux dialects; they are all supposed to be Christians, although many of them still believe in the power and charms of the medicine men. **Indians.**

Mr. Tait, the officer in charge of the post, says that good crops of peas, potatoes and other roots are raised here yearly, and are very rarely injured by summer frosts. This being the case, the country to the westward, between Severn and Sandy lakes, which is more favorably situated, having all the appearance of a better climate and a richer soil, must undoubtedly be well suited for agriculture, and will at some future time prove valuable land for settlement. At the Hudson Bay Post both our canoes were repaired; and on the 22nd of July, after securing the necessary provisions for the trip to the mouth of the river, and having determined the latitude of the place, we proceeded along the north shore to the north-east corner of the lake, where the Fawn branch of the Severn River flows out. This river, which varies from thirty to six hundred yards in width, was followed for eleven miles due north, where a small lake, three miles wide, was crossed. From here, for fifty miles, the river, with an average breadth of thirty yards, flows N.N.E., with a rapid current between low banks. Twenty-four rapids and chutes, caused by ledges of gneiss crossing the stream, occur in the distance, the greater number of which have to be passed by portages in ascending the stream, although only eight were made in descending. **Crops uninjured by frost.** **Fawn River.** **Rapids.**

At the rapids the river usually spreads out, and flows in several shallow channels between a number of small islands. This greatly increases the danger of damaging the canoes from striking against rocks on the bottom while running down stream. In its upper part the channel is greatly obstructed by large boulders strewn over the bottom, often rising to within a few inches of the surface, a good look-out being necessary to keep clear of them where the current is slow, as there is then no sign to show their position.

Obstruction caused by boulders.

Throughout this distance the surrounding country slopes towards the north and east with the river, which flows but a few feet below the general surface. Except the few small ridges of gneiss, the whole is swamp, covered with thick, wet moss, and supporting a growth of small black spruce and tamarac, with a few poplar clumps.

Swamp.

Northern limit of white birch.

On the islands is a better growth of white and black spruce, poplar and tamarac; the last white birch was seen near the end of this course. This region has a bleak, barren look, with soil totally unfit for cultivation, being wet without the possibility of drainage. Below the last chute the character of the river changes; it now flows with a swift current between banks cut in the drift sands and clays, but no rapids necessitating portages occur until within a few miles of the Forks.

Character of surrounding country.

The country above the river valley is comparatively flat and swampy, with clay subsoil overlaid by sand; the trees are chiefly black spruce and tamarac of small size, the greater part of which have been burnt. These characteristics prevail all the way to the mouth of the river, the whole country being practically useless.

The only timber large enough for small buildings grows on the islands and in the bottom of the river valley, where the soil is better and the high banks form a protection from the cold winds. Below the last chute the river first runs N. 50° E. for seventeen miles, then in a general course a few degrees south of east, twelve miles, to the Otter River, a large branch flowing from the south-east. For this distance the sloping banks of the river vary from ten to fifty feet high, and covered to the water's edge with a thick growth of small willows.

Otter River.

Below the Otter branch the river suddenly expands, being almost fifty yards wide, and gradually increasing with the descent; the channel is very shallow and interrupted by a great number of bars. The water, which on leaving Trout Lake was remarkably clear, gradually becomes discolored by the washing down of the clay banks of the river, and the dirty waters of small brooks that flow in.

High banks.

The valley now becomes deeper, the banks rising from fifty to one hundred feet, the upper part being cut almost perpendicular, with the lower part sloping gradually to the water's edge.

The willows do not grow so thick along the banks, which afford good tracking paths, used by the Indians in towing the boats up stream. Marks on the trees along the banks show that in spring the ice passes along fully fifteen feet above the summer water level. Good tracking paths.

From the Otter River the general course is about north-east for thirty-eight miles, then N. 30° E. twenty-one miles to the Picticiow River, flowing in from the eastward. Here a turn is taken westward, and the stream passes from bank to bank in a valley about half a mile wide, with a general course of N. 35° W. for fifty-six miles to the forks of the Severn. Six miles above this point beds of limestone rise from under the clay banks, and in crossing the stream cause several heavy rapids. Heavy rapids.

The Severn River, below the junction of the Fawn, is about half a mile wide. Beyond this, as far as its mouth, it varies from one quarter to one mile in width, the average being one-third of a mile. The cut banks are from thirty to two hundred feet high, gradually falling as the sea is approached. The channel is very shallow, and in places greatly obstructed by low gravel beds and sand bars. From the forks the general course is N.E. for sixteen miles, then N. 10° E. for twenty-three, where a fall of thirty feet, called the Limestone Rapid, occurs in one mile. This is caused by beds of limestone crossing the stream, forming a number of small islands, between which the river pours in heavy rapids. Obstructed channel.

The portage by which this obstruction is passed is on the west bank and over the bare limestone rock.

Besides this rapid there are several smaller ones, due to the same cause, but none are heavy enough to necessitate portages.

Below the Limestone Rapid the river again flows north-east to the sea, a distance of twenty-eight miles. Many large islands divide the stream into different channels for several miles from its mouth. Large islands.

We arrived at Fort Severn, situated on the west bank about four miles from the sea, on the 6th of August; thus finishing the micrometer survey from Lake Winnipeg to Hudson Bay.

Fort Severn is a small trading post of the Hudson Bay Company, resorted to by a few Indian families, the majority of whom live along the coast, making their hunts on the small rivers flowing into the bay, and living chiefly on geese, which are killed in great numbers in the spring and fall, while on their way to and from the breeding grounds of the north. The soil around the post is a heavy clay and very swampy. The climate is so cold and the season so short that nothing but a few small turnips are with difficulty grown here. On August 8th we picked strawberries on the clearings around the post; at that time they were only beginning to ripen. Fort Severn. Poor soil and cold climate.

It was the intention to return up the river to Severn Lake, from there to go by Trout Lake across the height of land to Cat Lake, and thence to Rat Portage; but on reaching Fort Severn the canoes were found to be so worn out as to make it impossible to return in them, and being unable to procure anything suitable for the trip at Fort Severn, we were obliged to coast along shore to York Factory.

Hudson Bay.

This we attempted to do in our canoes, and, leaving Fort Severn August 10th, in two days had reached Goose River, forty miles on the way. Here we were delayed by a heavy gale from the north-west, which continued for three days. On the second day a violent gust lifted the larger canoe over the stakes driven in the ground to secure it, and, rolling it over the ground, threw it against one of the tents, breaking it beyond repair. I immediately sent Mr. Macoun, with one man, on foot, back to the post with a request to send a boat and men enough to take us to York. They returned on the third day with a small whale boat and two Indians as guides.

York Factory.

Embarking, we coasted along shore, being greatly delayed by head winds, and reached York Factory on the 23rd of August, without other accident than the loss of our other canoe, which broke adrift from the boat while anchored off one night in a gale.

Character of the coast.

The distance between York and Severn is about 200 miles. The coast is quite flat and low, and is formed, for a considerable distance back from high water mark, of parallel ridges of gravel, from one to four hundred yards apart, the space between being filled up with sand and mud, and dotted with innumerable small lakes or ponds, the water of which is brackish behind the outer ridges, but quite fresh, clear and cold farther inland.

These ridges are each a few inches higher than the next nearer the sea, and drift wood is seen on each, showing more signs of decay on the inner than on the outer banks.

Evidence of the shores uprising.

This would tend to show that in this part of Hudson Bay the shores are slowly rising, as has been noted by other observers on other portions of the northern coasts.

Absence of trees.

The ebb and flow of the tide is between four and six feet. At low tide the water retreats a long way, exposing great sand and mud flats, with gravel ridges mostly parallel to the shore, and in many places thickly strewn with large boulders. From the mouth of the Severn to near Cape Tatnam no trees are seen from the shore; beyond this small black spruce come to within a mile or so of the water. The distance of the trees from the shore is due to the unfavorable soil rather than climatic influences. Between high water and the tree line the sand and gravel are almost bare, while the mud between the ridges is covered with a rich growth of grasses, affording fine feeding grounds.

Being unable to obtain canoes at York, we were obliged to travel in a heavy flat-bottomed boat. Leaving York August 26th, Norway House, at the head of Lake Winnipeg, was not reached until September 20th, great delay being experienced owing to the very low state of the water in the Hayes River and its branches. At Norway House our boat was exchanged for a lighter one, in which we coasted down the east shore of Lake Winnipeg, but were so delayed by rough weather that Selkirk was not reached until October 13th and Ottawa four days later. **Return journey**

GEOLOGICAL NOTES.

ARCHÆAN.

A.—Laurentian.

With the exception of some small bands of Huronian, the Laurentian rocks occupy the whole area of country between Lake Winnipeg and Trout Lake, and probably extend much farther to the eastward. **Distribution.**

Their northern limit on the Fawn River was not exactly located, the rocks being covered with drift, but it lies somewhere between the last chute on its upper portion and the limestone exposures near the forks; from the physical features of the valley, it is supposed to be near the former point. The rocks consist chiefly of the characteristic red micaceous gneiss, along with grey varieties, and also hornblendic gneisses. No limestones were noted. **Character.**

B.—Huronian.

The Huronian rocks were first observed on Favorable Lake, where they consist of chloritic and altered hornblende rocks, with talc and hydro-mica schists. The same band, presumably, was seen on Sandy Lake, and below it on the Severn River. The rocks in several places are highly magnetic, and probably contain large quantities of iron ore, both disseminated in small crystals through the rock and in large masses. Another band was met with at Trout Lake, in connection with a large mass of eruptive rocks. **Iron.**

Owing to the extent of the country covered in one short season, no strict investigation of these rocks could be undertaken, and it remains for another season to examine them carefully, both as regards their mineral characters and lithological relations.

2

PALÆOZOIC.

Cambro-Silurian and Silurian.

Age.

The limestones of the Severn and Fawn Rivers, as roughly determined from the fossils collected, are not older than the Galena, and may be as new as the Niagara, more investigation is, however, required to fix their precise horizon.

Character.

The rock is a coarse yellowish-white dolomitic limestone, closely resembling that of Lake Winnipeg. It lies almost flat, being broken only by long, low anticlines and synclines. At the Limestone Rapids of the Severn, where it is more contorted than usual, it rises in a number of low domes, closely resembling a sheet of letter paper when dampened. The total thickness of the beds exposed does not exceed one hundred feet.

POST TERTIARY.

Drift.

Evidence of ice action.

From Lake Winnipeg to Hudson Bay, almost all exposed rock surfaces exhibit distinct evidence of ice action, being strongly marked with glacial striæ, which vary in direction but a few degrees on either side of north-east, showing that the drift was from that quarter. Scattered all over the surface of the country are rounded boulders, many of great size and evidently far-travelled.

Drift.

The Severn and Fawn Rivers, for over 200 miles from their mouths, have cut valleys into the Post Tertiary deposits. As seen in the banks of these streams, where sections of 200 feet are obtained, the top beds are composed of a light sandy clay, containing many boulders of limestone, gneiss, red jasper and green chloritic and epidotic rocks. Below these are thin sandy beds, holding a large number of small boulders; while the lowest and thickest beds are made up of a heavy blue clay, comparatively free from boulders.

Fos

The following fossils were collected on the Fawn River, a short distance from the forks:—

Rhynchonella psittacea, Chemnitz.
Cardium Islandicum, Chemnitz. (=*C. ciliatum*, Fabr.)
Macoma calcarea, Chemnitz.
Mya truncata, L.
Saxicava pholadis, L. (=*S. rugosa*, Low.)
Buccinum tenue, Gray.
Trophon clatheatus, L.
And a small *Balanus*.

Botanical Notes.

It has been deemed inadvisable to publish with this report a list of the plants collected, as many species will probably be added during the next season, and after the country has been thoroughly explored a complete list will be published. A number of species were collected that were new to this portion of Canada and a few that are extremely rare. Among the most interesting may be mentioned *Aquilegia brevistyla*, Hook. in two localities on the Severn River; *Nymphæa odorata* Ait. *Var. minor*, Sims, growing in profusion between Severn and Trout Lakes. *Sisymbrium humile*, C. A. Meyer, was found a short distance from the junction of the Fawn and Severn Rivers, growing in gravelly soil; and along the coast, between Fort Severn and York Factory specimens were collected of a species supposed by Watson to be *Sisymbrium humifusum*, Hook., and has been so named provisionally by him. This species has not been found before on this continent, although reported from Greenland. Rare species.

A peculiar form of *Linum perenne*, L., with white flowers and of procumbent habit was noted in one locality along the coast. Although supposed to be rare, *Saxifraga Hirculus* L., grew in great abundance between Severn and York. Three specimens of *Cnicus Drummondii*, Gr., var. *acaulescens*, Gr., were collected along the Lower Severn, not before noticed east of the Saskatchewan. *Chrysanthemum arcticum*, L., and *Matricaria inodora*, L., var. *nana*, grow as far south as the mouth of the Severn. A form of *Primula*, that appears to be intermediate between *P. farinosa*, L., and *P. Mistassinica*, Mx., but placed by Watson with the latter species, was found growing along the coast below high water mark. *Scheuchzeria palustris*, L., is of frequent occurrence throughout the country. *Arctophila Laestadii*, Rupt., a rare and beautiful species of grass, recorded but once before, is quite common along the coast.

APPENDIX.

METEOROLOGICAL OBSERVATIONS TAKEN BY J. M. MACOUN ON THE ROUTE FROM LAKE WINNIPEG TO FORT SEVERN, BETWEEN FORT SEVERN AND YORK FACTORY AND FROM YORK FACTORY TO LAKE WINNIPEG.

The barometical readings are those of a small aneroid.

The temperature is stated in degrees Farenheit.

The force of the wind is estimated according to Beaufort's scale. The proportion of sky covered by clouds is estimated on a scale of 0 to 10, 0 being a cloudless sky, 10 an overcast sky. The character of the clouds is denoted by the usual letter or combination of letters referring to Howard's classification.

PLACE.	Date.	Thermometer.			Minimum.	Barometer.			Wind. Direction.			Wind. Force.			Weather.			Remarks.
	June	7	2	9		7	2	9	7	2	9	7	2	9	7	2	9	
Berens River, Lat. 52° 19′....	1	46	....	48	42	29.54	29.56	29.54	W.	W.	0.	3	3	0	R.	5 K.S.	10 K.S.	Squalls with rain all day.
Berens River..................	2	42	....	45	32	29.57	29.56	29.28	N.W.	W.	W.	1	4	1	C.	C.	C.	Strong wind, clear.
Berens River..................	3	42	....	58	32	29.46	29.25	29.27	W.	W.	W.	1	3	1	C.	5 K.S.	5 K.S.	
Berens River..................	4	58	....	64	52	29.36	29.86	29.32	N.W.	N.	N.	8	3	1	2 K.S.	C.	C.	Thunder storm during night.
Berens River..................	5	46	....	....	46	29.28	29.20	29.20	0.	0.	N.	0	0	8	C.	R.	C.	Rain from 12 to 3.30 p.m.
Berens River..................	6	56	....	....	55	......	......	......	0.	......	......	0	...	...	C.	....	....	
Family Lake, Lat. 52° 01′....	7	64	....	....	46	......	......	......	E.	......	S.	1	...	8	C.	....	6 K.S.	
Family Lake..................	8	....	....	....	...	......	29.06	......	......	E.	......	...	1	...	....	10 K.S.	....	Overcast all day.
Family Lake..................	9	....	....	60	45	......	29.11	......	......	S.	S.	...	1	1	....	2 K.S.	C.	Very warm during day.
Family Lake..................	10	60	63	63	50	29.04	29.08	28.94	S.E.	S.E.	S.E.	1	1	1	R.	R.	R.	
Family Lake..................	11	58	....	....	55	28.96	......	......	0.	......	......	0	...	...	5 K.S.	....	....	
Upper Berens River.........	12	68	75	60	59	28.88	28.86	28.84	S.E.	S.E.	0.	2	2	0	R.	5 K.S.	C.	Light rain in morning.
Upper Berens River.........	13	58	60	57	56	28.86	28.90	29.02	S.E.	S.E.	S.E.	3	8	1	R.	R.	R.	Rain all day.
Upper Berens River.........	14	56	59	51	48	28.81	27.49	27.41	W.	W.	0.	1	1	0	10 K.S.	4 K.S.	C.	Cloudy, threatening until noon.
Upper Berens River.........	15	60	65	55	45	28.41	28.85	28.34	W.	W.	W.	1	3	1	C.	7 K.S.	9 K.S.	Light showers during afternoon
Poplar River..................	16	46	63	55	40	28.45	26.71	28.73	N.	N.	N.	2	2	2	8 K.S.	10 K.S.	6 K.S.	Overcast all day.
Height of Land, Lat. 52° 24′..	17	45	59	55	35	28.72	29.46	20.48	N.	N.	0.	2	1	0	5 K.S.	4 K.S.	C.	
Black Birch Lake............	18	25	68	60	40	2.78	2.76	28.68	S.W.	S.W.	0.	1	2	0	7 K.S.	6 K.S.	C.	
Deer Lake.....................	19	50	61	56	42	29.06	28.98	29.00	W.	S.W.	E.	1	1	1	7 K.S.	R.	R.	Began to rain 10 a.m.
Deer Lake.....................	20	58	66	57	55	28.54	28.85	28.97	0.	N.E.	N.W.	0	2	2	R.	R.	8 K.S.	Ceased raining 8 p.m.
Deer Lake, Lat. 52° 44′......	21	56	74	63	46	28.80	28.73	28.76	N.W.	N.E.	0.	1	1	0	8 K.S.	C.	C.	

Deer Lake	22	60	75	65	55	28.91	28.91	28.93	S.E.	N.E.	0.	1	1	0	C.	C.	C.	
Deer Lake	23	65	85	63	55	28.91	28.85	28.78	S.E.	S.E.	0.	1	1	0	C.	3 K.S.	C.	
Deer Lake	24	65	79	60	55	28.78	28.62	28.62	S.	S.	S.	1	2	1	C.	8 K.S.	5 K.S.	
Severn River	25	65	80	63	58	28.74	28.85	28.97	S.E.	N.	N.	1	1	1	R.	7 K.S.	C.	Light showers at intervals during day.
Favorable Lake	26	64	78	60	58	28.9	29.01	29.02	S.E.	E.	0.	1	2	0	C.	C.	C.	
Favorable Lake	27	60	79	68	52	29.11	29.10	28.99	S.	S.	W.	1	2	1	C.	2 K.S.	5 K.S.	
Favorable Lake	28	68	77	69	61	29.02	29.00	28.94	W.	S.W.	0.	3	2	0	Smoke.	Smoke.	Smoke.	
Severn River	29	64	74	68	56	29.04	29.00	28.85	W.	W.	S.W.	1	3	1	Smoke.	Smoke.	Smoke.	
Lost Lake, Lat. 53° 16′	30	68	73	58	65	28.89	28.81	28.79	S.W.	S.W.	S.W.	2	3	1	Smoke.	Smoke.	Smoke.	
	July.																	
Muskrat Dam Lake	1	60	65	55	54	28.74	28.75	28.75	0.	0.	E.	0	0	2	R.	R.	R.	Began to rain 6 a.m.
Muskrat Dam Lake	2	65	73	65	58	28.73	28.60	28.58	S.W.	S.W.	S.W.	2	3	2	C.	C.	C.	
Muskrat Dam Lake	3	64	74	67	60	28.65	28.65	28.65	S.W.	S.W.	S.W.	3	3	1	C.	2 K.S.	C.	
Muskrat Dam Lake	4	61	78	68	54	28.75	28.76	28.59	S.	S.	S.E.	1	2	1	4 K.S.	6 K.S.	8 K.S.	Heavy gale from the south, beginning about 9.30, accompanied by very little rain. Lasted 1 hour.
Sandy Lake	5	62	77	69	58	28.65	28.67	28.73	S.	W.	N.	1	1	1	3 K.S.	Smoke.	Smoke.	Began to rain 11 p.m.
Sandy Lake, Lat. 53° 08′	6	64	72	63	61	28.88	29.00	29.09	N.	S.	W.	2	1	1	9 K.S.	9 K.S.	C.	
Sandy Lake	7	64	71	68	59	29.24	29.10	29.04	E.	E.	E.	2	1	1	9 K.S.	C.	C.	Fog until 9 a.m.
Sandy Lake	8	61	55	55	55	29.04	29.01	28.98	E.	E.	E.	1	2	2	9 K.S.	R.	C.	Began to rain 8.30 a.m. Ceased, 5 p.m.
Severn River	9	50	72	60	41	29.09	29.00	29.95	E.	S.	0.	1	1	0	C.	C.	C.	
Severn River, Lat. 53° 30′	10	56	64	58	52	29.09	29.09	28.08	E.	E.	E.	2	2	1	C.	9 K.S.	R.	Began to rain 8 p.m.
Severn River	11	58	69	61	42	28.92	28.93	28.89	E.	0.	0.	1	0	0	C.	3 K.S.	C.	Ceased rain during night.
Severn River	12	62	71	64	58	28.81	28.79	28.94	E.	E.	E.	1	3	2	R.	R.	8 K.S.	Began to rain 6.30 a.m. Ceased 4.30 p.m.
Severn River	13	61	74	64	56	28.98	29.10	29.19	S.E.	E.	E.	1	2	0	C.	4 K.S.	5 K.S.	
Severn River	14	64	71	68	61	29.18	29.14	29.00	E.	S.W.	S.W.	1	1	1	5 K.S.	4 K.S.	9 K.S.	Light showers between 7 and 8 o'clock p.m.
Severn River	15	65	58	46	62	28.94	29.04	29.09	S.W.	S.W.	N.	1	3	4	9 K.S.	8 K.S.	5 K.S.	Light thunder storms during night.
Severn River, Lat. 53° 54′	16	37	60	59	30	29.14	29.24	29.36	N.	N.	0.	3	2	0	9 K.S.	0	0	Light frost.
Severn Lake	17	47	66	61	42	29.32	29.32	29.19	S.E.	S.E.	0.	2	1	0	C.	C.	C.	
Trout Lake Portage	18	54	59	50	38	29.00	28.95	28.89	S.W.	E.	E.	2	2	2	10 K.S.	R.	R.	Began to rain 9.30 a.m. Wind changed to E.
Trout Lake Portage	19	54	60	53	40	29.00	29.03	29.08	N.	N.E.	N.E.	2	2	2	10 K.S.	5 K.S.	8 K.S.	Heavy showers between 3 and 4 p.m.
Trout Lake, 53° 54′	20	53	61	59	35	29.08	29.09	29.19	S.	S.	0.	1	1	0	9 K.S.	8 K.S.	C.	Light showers during forenoon.
Trout Lake	21	59	64	55	48	29.09	29.18	29.05	N.E.	N.E.	N.E.	2	2	2	R.	7 K.S.	R.	Heavy showers all day.
Trout Lake	22	49	71	68	36	29.11	29.14	29.12	S.W.	S.W.	0.	1	1	0	C.	C.	C.	
Fawn River	23	64	74	68	58	29.09	29.05	29.04	S.W.	S.W.	0.	2	2	0	9 K.S.	8 K.S.	C.	
Fawn River	24	68	64	59	61	28.98	28.91	28.85	S.W.	S.W.	E.	1	1	2	9 K.S.	8 K.S.	R.	Heavy thunder storm between 7.30 and 1 a.m.
Fawn River	25	54	68	61	46	29.07	29.06	29.11	N.	N.	0.	2	2	0	C.	C.	C.	Light showers during night.
Fawn River	26	61	63	59	54	28.99	28.97	28.94	S.W.	S.W.	0.	1	1	0	3 K.S.	R.	4 K.S.	Heavy thunder showers between 11 a.m. and 8 p.m.
Fawn River	27	58	64	58	44	28.99	27.04	27.14	S.W.	N.W.	N.W.	3	2	1	8 K.S.	7 K.S.	9 K.S.	Showers during night.

PLACE.	Date.	Thermometer.			Minimum.	Barometer.			Wind. Direction.			Wind. Force.			Weather.			REMARKS.
	July.	7	2	9		7	2	9	7	2	9	7	2	9	7	2	9	
Fawn River	28	48	61	57	36	29.18	29.10	29.08	N.W.	N.W.	N.W.	2	2	2	3 K.S.	5 K.S.	R.	Showers during afternoon. Rain all night.
Fawn River	29	54	62	58	43	29.08	29.4	29.09	N.W.	N.	N.	2	2	2	R.	9 K.S.	R.	Light showers during the day. Wind very changeable, but from the north the greater portion of the time.
Fawn River	30	60	68	60	45	29.22	29.27	29.41	N.W.	N.	N.	2	2	2	10 S.	10 S.	10 S.	Cloudy all day with light showers.
Fawn River	31	60	64	59	53	29.30	29.27	29.43	N.	N.	N.	2	2	2	10 S.	10 S.	10 S.	Cloudy all day with occasional light showers.
	Aug.																	
Fawn River	1	64	68	62	55	29.09	29.05	29.12	N.	N.	N.	2	2	2	10 S.	10 S.	10 S.	Cloudy all day with showers.
Fawn River	2	60	64	58	51	29.38	29.40	29.37	N.	N.	0.	1	1	0	10 S.	10 S.	C.	Cleared at 6 p.m.
Fawn River, Lat. 55° 07'	3	54	67	64	48	29.69	29.72	29.68	N.	N.	0.	1	1	0	C.	C.	C.	
Severn River	4	63	68	61	54	29.70	29.68	29.65	S.	S.	S.	1	1	1	4 K.S.	5 K.S.	8 K.S.	
Severn River	5	59	68	58	50	29.67	29.64	29.63	S.	S.W.	N.	1	1	3	C.	4 K.S.	R.	Heavy rain began 4 p.m.
Severn River	6	61	64	60	51	29.69	29.70	29.68	S.	S.	N.	1	2	3	4 K.S.	10 S.	10 S.	Stopped raining 6 a. m. Showers during afternoon.
Fort Severn, Lat. 55° 58'	7	54	61	51	48	29.81	29.86	29.88	N.	N.	0.	2	2	0	8 K.S.	10 S.	C.	
Fort Severn	8	58	66	60	50	29.89	29.87	29.80	S.W.	S.W.	W.	1	1	1	C.	C.	C.	
Fort Severn	9	48	67	60	32	29.91	29.93	29.98	S.W.	S.W.	0.	1	1	0	C.	4 K.S.	6 K.S.	
Hudson Bay	10	60	64	48	49	29.88	29.87	29.86	S.W.	S.W.	W.	1	1	2	3 K.S.	C.	C.	
Hudson Bay	11	49	51	48	33	29.86	29.84	29.82	W.	W.	N.	2	1	3	5 K.S.	R.	C.	Showers during day.
Hudson Bay	12	....	....	....	40	29.81	29.68	29.67	N.W.	N.W.	N.W.	4	5	5	R.	8 K.S.	9 K.S.	Heavy rain all night and until noon.
Hudson Bay	13	....	....	....	39	29.82	29.89	29.91	N.W.	N.W.	N.W.	5	5	5	8 K.S.	9 K.S.	7 K.S.	Light showers all day.
Hudson Bay	14	....	....	..	41	30.07	30.08	30.07	S.E.	S.E.	S.E.	4	3	2	C.	C.	C.	
Hudson Bay	15	....	....	....	35	30.00	30.00	30.01	S.W.	N.	N.	1	1	1	F.	C.	C.	
Hudson Bay	16	....	....	..	38	29.97	29.93	29.87	N.W.	W.	W.	1	2	2	C.	C.	C.	
Hudson Bay	17	..	....	....	48	29.87	29.81	29.85	N.W.	N.W.	N.W.	1	3	4	10 S.	7 K.S.	8 K.S.	Heavy rain during the fornoon.
Hudson Bay	18	....	....	....	50	29.89	29.91	29.94	S.	S.	S.	1	1	2	F.	C.	C.	
Hudson Bay	19	....	....	....	55	29.98	29.91	29.92	W.	S.W.	S.W.	2	1	1	Smoky.	5 K.S.	5 K.S.	
Hudson Bay	20	....	....	....	50	29.89	29.85	29.74	N.	E.	E.	1	1	2	F.	5 K.S.	8 K.S.	
Hudson Bay	21	....	....	...	48	29.58	29.75	29.77	E.	E.	E.	3	2	3	R.	3 K.S.	8 K.S.	Heavy showers during night and until 10 a.m.
Hudson Bay	22	...	....	....	51	29.74	29.75	29.78	E.	S.E.	S.E.	3	2	1	8 K.S.	5 K.S.	C.	
York Factory, Lat. 57°	23	....	..	....	54	29.88	29.88	29.82	W.	W.	W.	1	1	1	F.	4 K.S.	C.	
York Factory	24	....	....	....	36	28.81	29.76	29.7.	N.	N.W.	N.W.	1	2	1	Smoky.	Smoky.	Smoky.	

York Factory	25	....	....	....	38	29.49	29.53	29.67	N.E.	N.E.	E.	2	1	1	Smoky.	Smoky.	Smoky.	
York Factory	26	....	....	....	41	29.71	29.73	29.67	N.	N.	W.	2	2	8	Smoky.	Smoky.	R.	Began to rain 8 p.m.
Hayes River	27	....	....	....	48	29.71	29.77	29.79	W.	W.	W.	1	1	1	R.	8 K.S.	4 K.S.	Ceased raining 8 a.m.
Hayes River	28	....	....	....	43	29.77	29.58	29.38	W.	S.W.	S.W.	1	2	2	R.	Smoky.	Smoky.	Light rains at intervals during day.
Steel River	29	....	....	...	51	29.92	29.18	29.11	S.W.	S.W.	S.W.	1	1	1	Smoky.	Smoky	Smoky.	Light rainr at intervals during day.
Steel River	30	....	....	....	33	29.09	29.11	29.23	N.	N.W.	N.W.	1	2	2	Smoky.	R.	R.	Began to rain at 8 p.m.
Hill River	31	....	....	....	35	29.48	29.58	29.74	N.W.	N.W.	N.	2	2	2	9 K.S.	9 K.S.	5 K.S.	Ceased raining 5 a.m.
	Sept.																	
Hill River	1	....	....	....	30	29.48	29.59	29.74	0	N.W.	N.W.	0	1	1	R.	R.	4 K.S.	Light rain from 2 a.m. to 9 p.m.
Hill River	2	....	....	....	22	29.91	29.89	29.81	E.	S.W.	0	1	1	0	C.	C.	C.	
Hill River	3	....	....	....	34	29.59	29.55	29.38	0	S.W.	S.W.	0	1	1	Smoky.	Smoky.	Smoky.	
Hill River	4	....	....	....	54	28.17	29.24	29.27	W.	W.	W.	1	1	1	R.	8 K.S.	7 K.S.	Began to rain during night. Ceased raining 1 p.m.
Hill River	5	....	....	....	36	29.78	29.80	29.84	N.	N.	N.	2	2	2	9 K.S.	10 K.S.	8 K.S.	Cloudy and threatening but no rain.
Swampy Lake	6	....	....	....	52	29.82	29.79	29.74	E.	E.	E.	2	2	1	10 S.	10 S.	R.	Began to hail 3 p.m. Changed to rain 4 p.m.
Knee Lake	7	....	....	....	51	29.58	29.54	29.48	S.	N.W.	N.W.	1	2	1	R.	R.	C.	Stopped raining 5.30 p.m.
Knee Lake	8	....	....	....	27	29.58	29.37	29.19	W.	S.W.	S.W.	1	2	2	C.	6 K.S.	5 K.S.	
Knee Lake	9	....	...	....	55	28.88	28.91	28.98	S.W.	S.W.	N.W.	1	2	2	5 K.S.	10 S.	R.	Light showers during night. Began to rain 5 p.m.
Trout River	10	....	....	....	38	29.18	29.17	29.15	N.W.	N.W.	N.W.	2	2	2	10 S.	10 S.	10 S.	Rain changed to snow during night. Cloudy all day.
Oxford House, lat. 53° 45'	11	....	....	...	37	29.17	29.12	29.07	N.W.	W.	W.	2	4	4	C.	8 K.S.	7 K.S.	Flurries of snow last night and to-day.
Oxford House	12	....	....	....	28	29.02	28.88	28.97	W.	W.	W.	5	5	5	6 K.S.	8 K.S.	4 K.S.	Flurries of snow during day.
Oxford House	13	....	...	....	26	28.78	28.88	28.97	W.	W.	N.W.	5	4	2	6 K.S.	4 K.S.	5 K.S.	
Oxford Lake	14	....	....	....	27	29.17	29.16	29.05	W.	W.	W.	1	2	1	C.	6 K.S.	10 S.	
Side Pine	15	....	....	....	34	28.97	28.97	28.92	E.	E.	E.	2	2	2	R.	C.	R.	Began to rain during night
Robinson's Portage	16	...	....	....	36	28.88	28.91	28.98	E.	N.	N.	2	2	1	Snow.	R.	8 K.S.	Rain or snow all night. Rain changed to snow 8 a.m.
Height of Land	17	....	....	....	31	29.06	29.09	29.11	N.	N.W.	0	1	1	0	Snow.	Snow.	5 K.S.	Light snow all day.
Hairy Lake	18	....	....	...	20	29.24	29.29	29.34	N.W.	N.W.	N.W.	1	1	1	Snow.	Snow.	4 K.S.	" " " "
Nelson River	19	....	....	...	26	29.23	29.15	29.14	S.W.	S.W.	S.W.	1	1	1	4 K.S.	Snow.	10 S.	Showers at intervals during day.
Norway House, Lat. 85° 50	20	....	....	....	24	29.11	29.07	28.91	S.W.	S.W.	S.W.	1	2	2	8 K.S.	10 S.	R.	Showers in afternoon. Heavy rain began 5 p.m.
Norway House	21	....	....	....	45	29.01	29.09	29.21	E.	E.	E.	1	1	1	10 S.	10 S.	5 K.S.	Rain began 6 a.m.
Norway House	22	....	....	....	38	29.27	28.21	29.23	E.	S.E.	S.E.	1	1	1	4 K.S.	3 K.S.	10 S.	Showers in afternoon.
Lake Winnipeg	23	....	....	....	41	29.21	29.15	28.88	S.	S.	S.	3	2	3	10 S.	10 S.	10 S.	Showers during day.
Lake Winnipeg	24	....	....	....	38	28.84	28.91	28.95	S.W.	S.W.	S.W.	2	2	1	C.	4 K.S.	C.	
Montreal Point	25	....	....	....	33	29.06	28.96	28.88	S.E.	S.	S.	1	2	4	C.	C.	C.	
Montreal Point	26	....	....	....	44	28.81	28.76	28.73	S.W.	S.W.	S.W.	4	4	5	10 S.	10 S.	10 S.	Showers during day.
Montreal Point	27	....	....	....	38	28.69	27.67	27.71	W.	W.	N.W.	5	5	5	10 S.	10 S.	10 S.	Showers of snow, sleet and rain during day.
Little Black River	28	...	....	....	34	28.91	28.93	29.08	N.	N.	N.	3	2	3	10 S.	10 S.	10 S.	Very cloudy all day.
Poplar River	29	....	....	....	26	28.83	28.91	28.97	N.	N.	N.	2	2	3	Snow.	Snow.	Snow.	About 4 in. snow this a.m. Stopped snowing 4 p.m.

PLACE.	Date.	Thermometer.			Minimum.	Barometer.			WIND.						Weather.			REMARKS.
									Direction.			Force.						
	Sept.					7	2	9	7	2	9	7	2	9	7	2	9	
Poplar River	30	....	....	....	24	29.08	29.12	29.18	N.	N.W.	N.W.	4	3	2	10 S.	5 K.S.	C.	
	Oct.																	
Stony Point	1	....	....	....	28	29.34	29.19	29.08	E.	S.W.	S.W.	1	2	2	8 K.S.	C.	C.	
Leaf River	2	....	....	....	33	28.98	29.08	29.21	S.E.	S.	0	2	2	2	4 K.S.	C.	C.	
Berens River	3	....	....	....	35	29.15	29.19	29.23	N.	N.	0	1	2	0	C.	C.	C.	
Berens River	4	....	....	....	41	29.23	29.19	29.16	S.E.	S.	S.	1	2	1	C.	5 K.S.	3 K.S.	
Berens River	5	....	....	....	56	29.13	29.14	29.16	N.E.	N.E.	N.E.	2	2	2	8 K.S.	5 K.S.	C.	
Berens River	6	....	....	....	50	29.17	29.15	29.13	N.E.	N.E.	N.E.	1	1	1	C.	C.	C.	
Berens River	7	....	....	....	46	29.11	29.09	29.14	S.	S.	S.	2	2	2	Hazy.	Hazy.	Hazy.	
Berens River	8	....	....	....	43	29.19	29.17	29.21	0	0	0	0	0	0	10 S.	10 S.	4 K.S.	Showers in forenoon.
Berens River	9	....	....	....	46	29.06	29.00	28.88	E.	E.	E.	3	3	2	R.	R.	R.	Began to rain about 8 a.m.
Berens River	10	....	....	....	41	28.85	28.99	29.07	N.	N.	N.	1	3	2	10 S.	6 K.S.	8 K.S.	
Berens River	11	....	....	....	36	29.10	29.16	29.20	0	S.	S.	0	1	1	9 K.S.	5 K.S.	6 K.S.	
Berens River	12	....	....	....	41	29.38	29.31	29.15	S.E.	S.E.	S.	2	2	2	C.	3 K.S.	5 K.S.	
Dog Head	13	....	....	....	38	29.09	29.04	29.02	S.W.	N.W.	N.W.	1	1	2	R.	R.	R.	Rain all day.
Selkirk	14	....	....	....	34	29.01	29.14	29.38	N.E.	N.E.	N.E.	2	2	2	R.	S.	S.	Rain or sleet all day.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON

AN EXPLORATION OF PORTIONS OF THE

AT-TA-WA-PISH-KAT & ALBANY RIVERS,

LONELY LAKE TO JAMES' BAY.

BY

R. BELL, B.A.Sc., M.D., LL.D.

1886.

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1887.

To A. R. C. Selwyn, Esq., C.M.G., LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

Sir,—Herewith I beg to submit a report of my geological work during the season of 1886, a summary of which was handed you in December last, and published in the Report of the Minister of the Interior.

I have the honor to be,

Sir,

Your obedient servant,

ROBERT BELL.

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The work which I was instructed to carry on during the season of 1886 consisted, first, of an examination of the Grand Manitoulin Island, in order to verify the boundaries of the various formations which I had previously traced in 1865 and 1866, and which will now be laid down upon a map about to be published on a scale of four miles to one inch; and secondly, to make an exploration and survey of parts of the At-ta-wa-pish-kat River on the western side of James' Bay, and, if possible, to complete the survey of the Albany River. These objects were successfully fulfilled, and I shall now proceed to describe the results, and at the same time refer to the methods by which they were accomplished. Instructions.

In pursuance of the above instructions I left Ottawa on the 12th of June, and after spending two days in obtaining some necessary articles in Toronto, I proceeded to Manitowaning on Grand Manitoulin Island, and arrived there on the 16th. Eight days were devoted to the object above referred to, and as the roads and the weather were favorable, good progress was made, and the details of boundaries of the formations were accurately located over a large area in the townships of Sheguendah, Howland, and Bidwell. But as it was evidently impossible to complete the work before it became advisable to start for my more northern field, I left Manitowaning on the 24th of June, and Manitoulin Island.

Men and Assistants.

arrived at Sault Ste. Marie on the 25th. Here I hired six reliable men as voyageurs, and purchased a bark canoe. Leaving the Sault on the 27th, I arrived at Port Arthur on the 28th. Mr. John MacMillan and Mr. Alfred P. Murray accompanied me as assistants. Within an hour after arriving at Port Arthur, the whole party was sent on by the Canadian Pacific railway to Wabigoon, which had been selected as the point from which a start could be made on the best route to the region to be explored.

After purchasing most of our provisions for the season at Port Arthur, I proceeded to Red Rock, where I succeeded in obtaining a canoe from Mr. Newton Flannigan, of the Hudson's Bay Company. I might here remark that canoes large enough for our purposes have of late years become scarce and difficult to obtain. But I had arranged with Mr. Alex. Matheson, the H. B. Co.'s agent at Rat Portage, to have two ready for me, and these were now sent to Wabigoon. On the 1st of July, having forwarded my supplies and the other two canoes from Port Arthur, I proceeded to Wabigoon, arriving there on the 2nd. Our journey began with a portage about nine miles long, in a north-north-easterly direction, from Wabigoon to Big Sandy Lake. The four bark canoes were carried across this portage on our men's shoulders, while most of the supplies were taken by waggon over a "tote-road." While this work was in progress, I proceeded to Rat Portage to procure some necessary supplies from the Hudson's Bay Company, and returned on the 6th. The portaging having been completed on that day we crossed Big Sandy Lake, and camped at the south-western extremity of Minnietakie Lake.

Start from Wabigoon.

Routes Followed.

Sketch of routes.

Before entering into details of my exploration and its results, the description will be rendered clearer by the following short sketch of the routes followed throughout the season. From Wabigoon, a general north-easterly course was followed, via Lake Minnietakie and Lake St. Joseph, the Albany and Attawapishkat Rivers, to James' Bay. The water-shed between the rivers just named was crossed from the highest of the chain of lakes on the Eabamet Branch, by which we left the Albany at about 90 miles in a straight line below the outlet of Lake St. Joseph. On crossing the height of land we struck the head-waters of a branch of the Attawapishkat, having a north-easterly course. This we followed with much difficulty to its junction with the main river, a distance of about thirty miles.

Soon after passing the height of land, I decided to send back Messrs. MacMillan and Murray with two of the men from Sault Ste. Marie to

make a geological exploration of the route from Lake St. Joseph to Cat Lake and thence by Goose River to the west end of Lonely Lake. They explored about two-thirds of Cat River and returned via Lake St. Joseph and the route by which we had entered it. Cat River.

On arriving at the Attawapishkat River with my four men, I left the bulk of our stores in charge of one of them, and proceeded with the others to explore the river towards its source. Returning to this camp after a few days, we next descended the river to the sea, making a careful track-survey of it, taking numerous latitudes all the way to its mouth, a distance by the general course of the river of about 300 miles. We then coasted in our canoes to the mouth of the Albany River. A detailed track-survey of this large stream was made from James' Bay to "The Forks" or the junction of the Kenogami, above which point I had surveyed both branches instrumentally in 1871. The Kenogami was ascended to Long Lake, from which, passing over the Lake Superior height-of-land, we descended the Black River to its intersection with the Canadian Pacific railway. As I was obliged to convey my men home to Sault Ste. Marie, the most direct route for doing so was by way of Port Arthur, which we reached on the 13th of October. Albany River.

The different parts of the route above indicated will now be described with more particular reference to their geological features, but at the same time the geographical peculiarities, the aspect of each section, the timber, soil, climate, etc., will also be noticed.

Pelican River and Lonely Lake.

As the geology of the route between Wabigoon and Lonely Lake Post, via Frenchman's Head or "Lost Lake," was examined and reported upon in 1872, on this occasion, in order to explore new ground, I followed the main Pelican River from the point at which it turns off at right angles from Frenchman's Head Channel between Pelican Lake and Frenchman's Head Lake, and flows north-north-eastward into Lonely Lake. The Indians informed me that the outlet of Sturgeon Lake, which supplies a large part of the water of Pelican River, enters the north-east bay of Abram's Lake, and we ascertained in 1872 that the stream which we then descended, called Sturgeon Lake River, and which enters the eastern part of Minnietakie Lake, does not flow out of Sturgeon Lake at all. At a distance of six miles, in a straight line, from the above point of divergence from Frenchman's Head Channel, we came to the level of Lonely Lake at the foot of a slight rapid, down which we ran our loaded canoes without difficulty. The eastern part of Lonely Lake spreads itself in straggling Pelican River.

channels and bays over a much wider area than has hitherto been represented on the sketch-maps of the region.

Huronian rocks.

The Huronian rocks are everywhere met with from Wabigoon to the south side of Pelican Lake, where they give place to Laurentian gneiss. Near the junction with the latter, the Huronian schists run about west with a straight course, and the distinct banded structure which here characterizes them is nearly vertical. Both Abram's and Pelican Lakes are traversed by partially submerged ridges of boulders, having the same south-westerly course as the glacial striæ.

Gneiss of Lonely Lake.

Along the Pelican River, the rocks consist of grey, banded gneiss, of which the strike is for the most part between east and north-east and the lamination is on edge. Gneiss, of common red and grey varieties, continued all along our course through Lonely Lake to its eastern extremity, but a marked change was noticed in the strike in the narrow north-westward "jog," where its course was about north with a dip to the east of from 10° to 50°. About the middle of this section of the lake, the gneiss is much broken and mixed with granite. The shores of the eastern part of the lake are mostly marshy, but at the eastern extremity, massive gneiss is seen, and at a point on the north-west side, two miles from the extremity, the strike of a similar variety was observed to be north-west. It may be here incidentally remarked that gneiss with a little granite and a few trap dykes, are the only rocks which have been observed on any part of this sheet of water, which is nearly 100 miles in length.

Pelican River is the largest feeder of Lonely Lake, and as its waters are tolerably clear, they impart the same character to the lake west of its mouth, but to the eastward the water of the lake acquires the brownish color of Root River, which empties into its eastern extremity.

Root River.

Root River.

The general upward course of Root River, which is followed in going from Lonely Lake to Lake St. Joseph, has a north-easterly bearing, but the stream is very crooked, and it curves considerably to the south-eastward of a straight line. We followed this river to a point eighteen miles in a direct course from its mouth. Here the main stream bends off to the west, and we turned up a small branch from the north-north-east, which having no other name, we called Pond Lily Brook, and at the end of three and a-half miles, in a straight line, came to the height-of-land portage, half-a-mile long, leading over to the western extremity of Lake St. Joseph. The lower half of the eighteen miles of Root River which we followed, is a sluggish stream, expanding in several places into small lakes with wide marshy borders. On the

above route, massive gneiss is exposed in many places all the way from the east end of Lonely Lake to the west end of Lake St. Joseph. On the top of the nearly bare hills of gneiss, on the west side of Pond Lily Brook, half way between its junction with Root River and the height-of-land portage, some angular fragments of fine-grained siliceous magnetite were found. The height-of-land portage, which rises only a few feet above the level of Lake St. Joseph, passes over bouldery and clayey ground, with a bog in the middle. Magnetite.

LAKE ST. JOSEPH.

In 1885, Mr. Thomas Fawcett, D.L.S., measured a zig-zag line through Lake St. Joseph by means of the Lugeol micrometer, the angles being taken with the transit. In constructing the accompanying map, his distances have been adopted, while the details are taken from my own sketching, based on a track-survey made by a floating boat-log and careful timing of the speed of my canoe, all bearings being taken by a good compass. Map of Lake St. Joseph.

The mean of ten barometric observations, noted on as many different days, on Lake St. Joseph, give its elevation as 1,172 feet above the sea. Its general course is east-north-east, true, and its length from the western extremity to the northern of its two outlets at its opposite end, is fifty-eight miles, and to the more southern outlet fifty-five miles. The breadth varies from a quarter of a mile to three miles, with an extreme width of eight, measuring across points, but the average would be about one mile and a-half. It may, therefore, be described as a narrow straggling sheet of water of the above dimensions, the area of its water-surface being much reduced by the points and peninsulas and the great number of islands of all sizes, from three miles in length downward, which it contains. The largest space of open water is the Grand Traverse, at about two-thirds of the distance from the west end, which is three miles wide and measures eleven miles from south-west to north-east. Level of Lake. Dimensions.

The country around Lake St. Joseph may, in a general way, be said to be level, although some low rocky hills are to be seen in places. Ridges of granite, nearly destitute of timber, occur around the western mouth of Cat River, not far from the west end of the lake. To the eastward of the first narrows, east of the eastern mouth of this river, rounded hills of gneiss may be seen on both sides; and again on the west side of a northern arm, fifty miles from the west end. In the narrow section towards the east end, which has a general south-east course, but in which all the points and bays run north-east and south-west, a few low ridges of gneiss run parallel with these, and some long Surrounding country.

rows of boulders or moraines, rising just out of the shallow water, have the same direction. It will be observed that while the general course of the lake is about east-north-east, the bays and points run more nearly north-east and south-west. A table of the directions of the glacial striæ is given further on, from which their average bearing will be seen to be south-west, thus corresponding with the general trend of the depressions in the face of the country. At the "Fall Fishery Station," forty-four miles from the west end, the surface of the quartzose gneiss, which occurs there, is thoroughly planed off, and along with the striæ, running S. 30° W., the bruised crescent-shaped marks, indicating great pressure, may be seen following each other in rows, their concavities looking south-westward, showing that the glacial movement was in that direction.

Glacial striæ.

Soil.

It would be difficult to estimate the proportion of cultivatable soil compared with the worthless area in the country adjacent to the shores of Lake St. Joseph, but the percentage does not appear to be great. In some places, both on the main shores and the larger islands, low banks of sand and of yellowish loam were seen, but, as a rule, the surface appears to be either too stony or too level and wet to give much promise as a farming region. The Indian name of Lake St. Joseph is "the lake of the swampy country."

Climate.

The climate in the immediate vicinity of the lake, at all events, appears to be sufficiently good to admit of the growth of a variety of crops. At Osnaburgh House, near the east end, where the soil is of a sandy nature, the principal crop cultivated at present is potatoes, but early Indian corn, peas, beans, and a variety of roots and other vegetables, to say nothing of a profusion of flowers, were in a flourishing condition in the end of July. In former years, when cattle were kept at the post, barley was said to have been a regular crop. Hay grows very luxuriantly. I was credibly informed that pumpkins and musk-melons had frequently ripened at this establishment.

Timber.

The timber all around Lake St. Joseph has suffered greatly from forest fires at many different times from about a century ago to the present year. Parts of the main shores and many of the islands, especially in the neighborhood of the Grand Traverse, have escaped the fires, and here full-sized timber may be seen. The second growth woods are of all ages, from seedlings of a year or two, up to trees nearly as large as those of the original forests. As elsewhere in these latitudes, where the old forests of spruce, tamarac, balsam, white birch, etc., have been burnt, they are succeeded by a growth of mixed aspens and white birch, with a sprinkling of spruce, or else by one consisting almost entirely of Banksian pine. In regard to relative abundance, the trees found around the lake may be mentioned in the follow-

ing order:—white and black spruce, tamarac, aspen, white birch, Banksian pine, rough-barked poplar, balsam, white cedar, pigeon cherry, rowan and black ash. The ground or mountain maple (*Acer spicatum*), which is interesting as an indicator of climate, is common, and it was traced for a long distance down the Albany. Of the above kinds of timber, the white spruce and the tamarac are the most important commercially. The cedar is confined chiefly to the immediate shores of the lake, where it often forms a continuous but narrow border. It has the same habit around the other lakes and along the rivers in the whole of this part of the Dominion. But it is also frequently found in large patches in the inland swamps of these regions. About twenty spruce logs, for sawing into boards, were lying at Osnaburgh House at the time of our visit. They would average eighteen or twenty inches in diameter at the butts, the largest being about two feet. The six largest showed the following number of rings of growth:—113, 97, 121, 116, 107, and 120, or an average of 112, these rings indicating, it is supposed, a corresponding number of years. A new tamarac flagstaff, which was about to be erected, measured about eighteen inches in diameter at the butt and showed 244 rings of growth. **Saw logs.**

The number of Indians living around Lake St. Joseph is not very great. They live principally upon fish in summer and rabbits in winter, but these resources are supplemented by geese and ducks in the spring and autumn, and occasionally by larger game, such as carribou and bears at any season. The fishes of the lake comprise white-fish, grey trout, sturgeon, pike, pickerel, yellow-barred perch, grey and red suckers, besides some smaller species. **Indians.**

Rocks of Lake St. Joseph.

The rocks observed on the shores of Lake St. Joseph will now be described. Leaving the portage at the west end of the lake, massive grey gneiss, striking about east and west, occurs on both sides at between two and three miles, and again on the north side at four miles and a-half, where it strikes S. 80° W. About a mile further on the rock has changed to a light pinkish-grey granite of medium texture, which consists principally of felspar and quartz, the mica being in very small quantity. This rock extends up the channel which forms the western mouth of Cat River, for at least four miles, but the channel was not explored any further. Along the main channel of the lake, beginning at six miles from the extremity, a soft, glistening, green, calcareous schist flanks this granite on its south side. This schist continues for ten miles, with a strike varying from S. 60° W. to S. 70° W. A small island at eighteen miles, consists of coarse, massive grey siliceous schist, **Gneiss.** **Granite.** **Green schists.**

striking west. Another small island, half-a-mile north of the last, is formed of massive dark greenish-grey dioritic schist. A similar schist, running N. 80° W. was found on another island two miles further on, or about three miles east of the eastern mouth of Cat River. Half a mile east of the last-named island, a grey rusty-surfaced mica schist on a small island was found to run N. 60° W. At the western entrance of the narrows, twenty miles from the west end of the lake, green schists strike N. 50° W. The long island in these narrows consists of dioritic schist and conglomerate. An islet on the north side of the eastern entrance of these narrows, or about seven miles E. by S. of the eastern mouth of Cat River, consists of a massive coarse crystalline hornblende rock, becoming somewhat schistose on the south side. Its strike is east and west.

Dioritic schists.

Conglomerate.

About a mile east of the last mentioned islet, both shores of the lake were found to consist of gneiss, so that the dividing line between the Huronian and Laurentian, which occurs in this interval, will be about twenty-four miles, in a straight line from the western extremity of the lake. Time did not permit of a fuller examination of the Huronian rocks of the western part of Lake St. Joseph, but the foregoing examples will serve to give an idea of their characters which, it will be observed, are somewhat varied.

Gneiss.

Strike.

The gneiss near its contact with the Huronian schists, and for some distance onward, strikes east and west, or parallel with the latter. At thirty-eight miles from the western extremity of the lake, a long bay runs off to the north-eastward. The gneiss in its vicinity is of a hornblendic character, and its strike is S. 45° W. On the northern shore of the lake, forty-four miles from the west end, is the fishing station, already mentioned, at which large quantities of white-fish are taken late in the autumn or just before the ice forms. At this place the rock consists of light grey gneiss. A northward arm of the lake runs for six miles beyond the fishery, and the massive light-colored gneiss extends all the way to its extremity.

Huronian rocks.

The rocks of the eastern part of the lake correspond with some of those of the Huronian series. On the northern side, at four miles from the southern outlet, or three miles from the Hudson's Bay Company's post called Osnaburgh House, which is situated opposite to this outlet, a grey mica-schist dips S. 60° E.<60°, or strikes S. 30° W. It is cut by a wide vein of coarse light-colored granite, in which a considerable proportion of mica is mixed with the felspar and quartz. Opposite to this point is the mouth of a small river, called the Pedler's Path, which forms part of a route to Lake Nipigon. My assistant, Mr. Murray, ascended it for about six miles, in which distance he passed through three small lakes. He found the rock at the mouth to consist of rather

Mica schist and granite.

Pedler's Path.

fine-grained hornblendic schist, striking west. The long bay running northward from Osnaburgh House, was examined by Messrs. Murray and MacMillan to the extremity, from which the northern outlet of the lake flows. They found the rocks along the western shore to consist of hornblende and mica-schists with some fine-grained gneiss, all striking about east and west, except at the northern extremity of the bay, where a fine-grained gneiss had a north-westerly strike. The schists are traversed in several places by large veins of coarse granite, which having resisted denudation better than the surrounding rock, stand out as small points in the lake. On the east side of this bay, gneiss was the only rock observed north of the southern outlet, where, however, a grey mica-schist, striking north-west, occurs along with light-colored coarse granite. East end of Lake.

This completes the description of the geology of Lake St. Joseph as far as I was able to investigate it in the limited time at my disposal. It will be observed that the prevailing rocks around it are gneisses, but that Huronian schists, etc., extend between seven and twenty-four miles from the west end, and are again developed around the eastern extremity; also that granite prevails about the western mouth of Cat River, and this rock will be shown to extend from near the southern outlet of the lake for a considerable distance down the Albany River.

Albany River—Upper Section.

Leaving Lake St. Joseph by the southern outlet, at two miles down the Albany River, which takes its rise in this body of water, we came to Hugh's Creek Portage, on the north side, 460 paces long, with a descent of ten feet in the river. The rock is here dark green, fissile, hornblende schist, striking N. 65° W., nearly vertically. From the foot of this rapid an expansion of the river, called Deep-and-Shoal Lake, extends north-westward to the rapids at the northern outlet of Lake St. Joseph. A river without any recognized name enters the Albany from the south, six miles below the southern outlet. Two miles below Hugh's Creek Portage, a light pinkish grey granite makes its appearance on the points and continues for nine miles, or to the northern outlet of an expansion, three miles wide, called Atik-o-ki-wam or Deer Lodge Lake, which has two discharges that unite again only nine miles further down. The Albany, with its lake-like expansions, from its head at Lake St. Joseph to Deer Lodge Lake is shallow, and full of angular and rounded boulders of granite. The shores are mostly low and covered with brush and grass alternating with knobs of granite. The timber further back was burnt two or three years ago. At the northern outlet of Deer Lodge Lake, the rock is a somewhat Hugh's Creek Portage. Granites.

Diorite.

coarsely crystalline diorite, having a bright fracture, the crystals of black hornblende and white felspar together, giving it a general dark grey colour. It probably belongs to a large dyke cutting the granite.

Smooth Stoney Portage.

From Deer Lodge Lake we followed the northern and larger channel, which is broken by numerous rapids. Portages are required at four of these, the first being the Smooth Stoney Portage on the north side, at four miles, 715 paces long, with a fall of thirty-six feet. The others are called the three Kagami Portages, and all occur in the last mile before arriving at the junction of the two channels.

Kagami Portages.

The 1st Kagami Portage, on the N. side, has a fall of five feet, and is 100 paces long.

The 2nd Kagami Portage, on the S. side, has a fall of 27 feet, and is 750 paces long.

The 3rd Kagami Portage, on the N. side, has a fall of eighteen feet, and is 570 paces long.

Granite.

Between the diorite at the outlet of Deer Lodge Lake and Smooth Stoney Portage, granite occurs in several places. At one locality in this interval a granitoid rock showed traces of lamination, running north-easterly. At the portage just mentioned, a massive grey granitic gneiss strikes N. 30° E. At the first and second Kagami Portages the rock consists of fine-grained reddish grey granite, in which quartz is the most and mica the least abundant constituent; while at the third of these portages it is a pinkish-grey gneiss striking N. 60° W., with vertical lamination. A great rapid or chute occurs in the southern channel from Deer Lodge Lake where it falls into the other branch opposite to this portage.

Gneiss.

Etow-i-ma-mi River.

From the foot of the long island just described, the general course of the river is north-eastward to the junction of the Etow-i-ma-mi River, from the northward, a distance of thirty miles. It is considerably broken by rapids, but we ran our loaded canoes down all except two of them, at which portages required to be made. Gneiss, which was generally coarse, grey, and massive, was observed in several places in the above thirty miles, and wherever the lamination was apparent, the strike was to the northwestward. At a southward angle of the river, about eight miles above the Etow-i-ma-mi branch, the Mischkow River falls in from the south.

Huronian rocks.

Below the Etow-i-ma-mi the Albany turns south-east for five miles, when it is joined by the Sha-bush-quai-a River from the southward. At two and a-half miles below the former branch, Huronian rocks make their appearance. They consist of light-greenish, rather finely crystalline hornblende schist; black, with some light colored schist, together with fifteen or twenty feet of fine-grained banded magnetic iron ore with slaty partings. A specimen of this ore was analysed by Mr.

Iron ore.

Kenrick of the Geological Survey, and found to contain 42·09 per cent. of metallic iron, and to be free from titanic acid. Along with the magnetite is a band of iron pyrites, a few inches thick, with traces of copper. These rocks are so much disturbed that it is impossible to determine their strike. The joints in the hornblende schist are slickensided, and many of them are occupied by strings of calcspar.

A dark green hornblende schist occurs at two miles before coming to the Sha-bush-quai-a River, and strikes N. 70° E.$<$90°. It holds patches of calcspar and quartz running with the cleavage. Hornblende schist.

The Eska-qua, or Green Bush Portage, being the 8th from Lake St Joseph, is met with at a mile and a-half below the Sha-bush-quai-a River. It is on the right or south side, and is 505 paces long. There is a nearly perpendicular fall in the river of fifteen or twenty feet, and the total descent at the portage is about twenty-five feet. The rock is a soft, green schist, striking N. 85° W. with great regularity. Specks of copper pyrites were found in small quartz veins in the schist at the foot of the fall. A mile below this portage, similar schist and a hornblende rock, having a pitted weathered surface, strikes S. 80° W. Green Bush Portage. Copper pyrites.

The Lower Eska-qua, or 9th Portage, on the right side, and 185 paces long, with a descent of twenty-five feet, occurs at two miles below the last. Soft green schist with calcspar in the joints and cleavage-planes is found here. One band shows a concretionary lenticular structure. The strike is S. 65° W., with a south-eastward dip of 75°.

The head of the 10th, or Snake Portage (Kenaibik Inigum), on the left side, is a mile and a-half below the last. It is 480 paces long, and the descent in the river is ten feet or more. Soft, green schist, striking S. 75° W. is here largely exposed. Much of it has the concretionary structure so often observed in the Huronian schists. It is traversed by a band or dyke of coarse, grey felsite, from nine to thirteen feet wide, in which grains of blue quartz are thickly disseminated. Its general course crosses the cleavage of the schist, but it bends suddenly at an angle of 55°. Large glacial furrows, running in a south-westerly direction, occur at Snake Portage. Between this portage and the inlet of Maminiska Lake, four miles further on, chloritic schists are exposed in two places, the strike ranging from S. 10° W. to S. 25° W., the bedding or cleavage being vertical. Snake Portage. Concretionary green schist.

The country on either side of the Albany River, all the way from Lake St. Joseph to where the Huronian rocks commence, below the Etow-i-ma-mi branch, is generally level, few hills of any kind being seen. The shores of the river are rocky or bouldery, but the banks often show gravel, sand, loam, and clay. But from the last-mentioned locality to Maminiska Lake and to the south of this sheet of water, numerous earthy-looking hills are visible. Wherever a view can be Character of country.

obtained over the country, long slopes or gentle undulations may be seen, the hill-sides being covered either with old timber or a second growth of aspen and white birch. Some small grey elm trees were observed at the inlet of Maminiska Lake, being the first noticed since leaving Minnietakie Lake, where a single small tree of this species was seen. A grove of black ash occurs with the elms, but this tree is not uncommon along the Upper Albany.

Elm and ash.

Maminiska Lake.

Maminiska Lake runs north of east, and is about sixteen miles long. It is divided by a very narrow place, about half-way down, into two equal parts, each three miles wide. The rock at the narrows consists of a hard close-grained diorite, of a somewhat concretionary character. An obscurely stratified appearance in it has a west-south-westerly bearing.

Cedar River and Lake.

Cedar River enters the north side of the lower division of Maminiska Lake. An Indian, whose hunting grounds surround Cedar Lake, at the head of this river, described it as being about the size of the lower division of Maminiska Lake, and containing many islands. It would appear to lie about thirteen miles north of the latter. He said there were six portages on Cedar River between the two lakes.

The outlet of Maminiska Lake is on the south side of the eastern half, and, after a rapid descent southward of two miles, the river falls into the head of Patawonga Lake.

Diorite.

Quartz veins.

The 11th Portage, 110 paces long, by which we got past a steep chute, with a fall of eighteen feet, is on the left side, and about midway between the two lakes. The rock at this chute is a coarse, grey stratified concretionary diorite, with spots of light-coloured felspar, and a smaller proportion of spots and patches of green epidote scattered irregularly through it. It strikes west, dipping southward at an angle of 60° to 70°, and contains a good many irregular veins of quartz, holding epidote and hornblende, the veins for the most part running with the stratification. A number of these veins, from three to fourteen inches thick, were carefully examined for metallic ores, but none could be detected.

Patawonga Lake.

Huronian schists.

Patawonga Lake is about thirteen miles long, with a course bearing to the south of east, and varies from half-a-mile to two miles in width. It is surrounded by a level country. Two rivers flow into it from the south and one from the north. On the south side, near the outlet, schists, supposed to be Huronian, standing in a vertical attitude, strike east and west. An islet, about midway between the extremities, consists of a gneissoid rock, composed of quartz, hornblende, and a triclinic felspar, striking N. 75° W. Ordinary gneiss occurs on an island in the outlet.

Within the first two miles from the outlet of Patawonga Lake there is a strong rapid, with a descent of from twenty to thirty feet, requir-

ing a portage (the 12th) of a few hundred yards, but it varies in length according to the height of the water; and at three miles the river falls into Ka-wi-tos-kam-igamog Lake. This is five miles long and has a north-easterly course. It is remarkable for having a straight ridge of drift which forms an island nearly two miles long, running down the middle of its lower part. The 13th Portage, 290 paces long, crosses part of an island at one mile below the last lake, and the descent in the river is about twenty feet. Gneiss was observed in two places in the next two miles. At the end of this distance we entered a lake measuring about two miles along its north-west side, and which from its shape might be called, for convenience, Triangular Lake. The Eabamet River enters the north-eastern angle of this lake, while the downward continuation of the Albany flows out of its south-eastern corner. From the junction of the Etow-i-ma-mi, mentioned above, to this lake, a distance of upwards of forty miles, the general course of the Albany has been about east, but it now turns south-east. Triangular Lake is within twenty miles of Abazotikitchewan Lake, at which I struck the Albany in 1871 when making a micrometer survey of a canoe-route from Lake Nipigon. From this point, the survey of the river was then carried down-stream to The Forks, or junction of the Kenogami. In order to connect the upper part of the river with this survey, I sent Messrs. MacMillan and Murray to make a track-survey of the intervening link. They found the distance to be about twenty miles and the general course of the river south-east, as just stated, with only one rapid requiring a portage, between the points referred to. In this stretch, the river has the same general lake-like character which it has maintained from the head of Maminiska Lake, a distance of twenty-six miles, and which continues to the foot of Makokibatan Lake, about thirty-four miles below Abazotikitchewan Lake, or for eighty miles in all.

12th portage.

Eabamet River.

Connecting surveys of Albany River.

Lake-like character of river.

Mr. MacMillan found gneiss here and there on the shores of the Albany for about half the distance from Triangular Lake to Abazotikitchewan Lake, but in the second part of the distance, hornblende schists, striking east and west, continued to the north side of the latter lake, where I had found similar rocks with granite and trap in 1871. Gneiss, with a west and north-west strike, was then described as occurring all around the southern part of the last mentioned lake. (Report of Progress for 1871, page 109.) The breadth of the hornblendic schist belt is apprently between six and seven miles, at right angles to the strike, and it is perhaps connected with the Huronian belt which I found between Lake of the Narrows and Martin's Falls, and which appears to be folded and repeated to the north of the part of the Albany referred to. (Same report, page 110.)

Belt of hornblende schist.

Leaving the Albany and following up the lowest section or link in the Eabamet River, a small stream unbroken by rapids, we entered Eabamet Lake at a distance of only about one mile. This sheet of water runs east-south-east and is about eleven miles long by one mile and a-half wide, and the stream by which we entered it flows out near the middle of the south-western side. In the vicinity of the outlet, micaceous gneiss dips S. 80° E. $< 45°$. About a mile from the upper end of the lake on the same side, ordinary grey gneiss strikes north-westward. On the north-east side, four miles from the upper extremity, a very micaceous grey gneiss, passing into mica-schist, strikes N. 60° W. and dips north-eastward at an angle of 70°. It is cut nearly at right angles to the strike by irregular dykes of a coarse, light grey granite, with branches following the lamination, holding considerable numbers of grains and small crystals of a green mineral which Mr. Hoffmann finds to be apatite.

Eabamet Lake.

Micaceous gneiss.

Apatite.

From the head of Eabamet Lake, the river is rapid and has an upward north-westerly course of three miles, with Round Lake (one mile in diameter) half way, and we then enter Fishing Lake. The rocks between these lakes consist of dark grey compact felsite in very even laminæ and green dioritic schists, interstratified with a grey gneissoid rock, containing a triclinic felspar. The strike is east and west. These rocks are classified with the Huronian.

Felsite and dioritic schists.

Fishing Lake.

Fishing Lake runs north-north-east and is about eight miles long. No fixed rocks are seen on its shores. The rapid stream flowing into the head of Fishing Lake has an upward northerly course of four miles, and flows out of a lake about a mile wide and six miles long, running north-west. Coarse, grey gneiss occurs at the outlet of this lake. This point is thirteen miles north of the last gneiss seen near the head of Eabamet Lake, and as the strike of the Huronian rocks above the latter is east and west, the belt to which they belong has a possible width of the above amount, but it probably does not extend more than eight miles north of the head of Eabamet Lake, and it may be connected with the Huronian belt to the south-west, extending along the Albany from near the Etow-i-ma-mi branch to the outlet of Patawonga Lake, a distance of about thirty miles. Continuing northward from the six-mile lake referred to, after ascending another short link of river, less than a mile long, we entered a lake which also measures six miles from south to north, but which has an extreme width of about five miles. The shores of this lake, almost all the way round, consist of boulders and shingle. Gneiss was found *in situ* at three places in the northern part. The surrounding country is level, with the exception of an isolated hill about two miles from the south-west side of the lake, which is conspicuous from the rarity of any inequalities in the

Huronian belt.

R. BELL. PHOTO., 1886. IVES-PROCESS; G. E. DESBARATS & SON, MONTREAL.

BOULDER RIVER, NEAR ITS SOURCE;
SHOWING THE GENERAL CHARACTER OF THE STREAMS ON THE HEIGHTH OF LAND S.-W. OF HUDSON'S BAY.

surface of the country in this region, no other hills having been seen on our route since leaving Maminiska Lake.

From the lake last described, we would have reached the Attawapishkat River most easily by crossing the height-of-land to the north-westward and descending the Martin-drinking River. We afterwards learned that the first portage leading to this stream leaves the western bay of the lake, and not the north-western, where we searched for it in vain. Route to Attawapishkat River.

Having no guide, we followed the only route we could find—one which left the north-eastern extremity of the lake by a short portage into a tributary lake, four miles long, running in a north-easterly direction. From the head of this lake we crossed the height-of-land by a portage 880 paces long, and came to a lake one mile long, from which the water flowed north-eastward. The variation of the compass in this vicinity, from my observations, would appear to be less than 1° E. Height of land.

BOULDER RIVER.

We descended the small river which has its source in this lake, to the Attawapishkat River, and found the distance, in a straight line, to be about twenty-five miles. The Indians do not navigate this stream, and as they have no name for it, we called it Boulder River, from the very bouldery character both of its bed and the country on either side. Boulder River. Its general course is pretty straight, and bears a little east of north-east. It consists of a series of short stretches of dead water, with bouldery rapids between them. At most of these, we were obliged to make portages on account of the small quantity of water flowing among the closely crowded boulders, although the descent might not be great. In some cases, however, a clear channel, down which canoes could be run, was formed through the midst of beds of boulders. The formation of these curious channels, which I have observed at bouldery rapids in many of the smaller rivers, north of the great lakes, may be due to the action of frazil or anchor ice in buoying up the boulders, so that they might be rolled or partially floated down the rapids by degrees, from year to year, until the existing channels were formed. Natural channels among boulders. We managed to float our canoes down some of the numerous rapids of this river by removing boulders. This process was resorted to whenever it could be done in less time than would be consumed in cutting out a portage-trail, unloading the canoes, carrying over everything and reloading. But in addition to clearing a considerable number of such channels, we made upwards of thirty complete portages, which required the trails to be cut through the woods in every instance. All 30 portages.

these operations entailed a great amount of labor, occupying from the 5th to the 18th of August. Soon after crossing the height-of-land, I left most of my party to bring on our larger canoes and supplies, and pushed on in a light canoe to the junction of Boulder River with the Attawapishkat, in order to ascertain whether it was possible to reach the latter at all by this route.

Sturgeon Lake.

At seven miles before joining the Attawapishkat, Boulder River falls into a lake, three miles long, which the Indians call Sturgeon Lake, from the abundance of this fish to be found in it. While in the act of setting our gill-net, the evening we camped on its shores, a sturgeon, measuring upwards of five feet in length, was caught in it. Below Sturgeon Lake, the river is not so difficult as above; and after having advanced nearly to this lake with a sufficient supply of provisions for the remainder of the season, I sent back Messrs. MacMillan and Murray with two canoemen, as already stated, and continued the exploration with the aid of the remaining four voyageurs.

Country on either side of Boulder River.

While the labor of cutting out portages and transporting our supplies was going on, numerous observations for latitude were taken, and I also explored the country for some distance on either side of Boulder River through a considerable part of its course. The surface consists of a series of rounded bouldery ridges of no great height, irregularly disposed, but running generally in a north-easterly and south-westerly direction, with swampy spaces, covered with a deep hummocky growth of sphagnum moss between them. In some sections, the timber had been burnt off the ridges and dry parts, exposing the naked surface, which was then seen to consist of boulders of all sizes and of a variety of kinds, mixed with some gravel and sand, and presenting a sterile and forbidding appearance.

Timber.

On the dry ground, the timber consisted of black spruce, tamarac, balsam, aspen and white birch, but on the wet level tracts, it was principally black spruce. All the rapids in Boulder River were overhung by thick groves of good-sized white cedar, and the same tree was met with in groups in some of the swamps at a distance from the river. The rough-barked poplar occurs near the stream, but was seldom seen inland.

Rocks.

Common varieties of gneiss were noted in a number of places in the bed of Boulder River. There was no regularity in the general strike. Locally, the gneiss ran in various directions, from north-west to south-west.

Upward exploration of Attawapishkat River.

Having reached the Attawapishkat River, I left my supplies in charge of one man on an island, half a mile long, which I called Nolin's Island in his honor, and taking the other three men, proceeded to explore the upward course of the stream. Its general direction was

found to be about W. by N. At three miles we came to a very steep rapid, with a rise of fifty to sixty feet in about a mile and a quarter, which, for convenience, I called the Long Rapid. Notwithstanding the strength of the current my men poled our canoe all the way up. No rock *in situ* is seen, but nearly all the boulders which form the bed and shores of Long Rapid are more or less angular, and consist of an indistinctly and coarsely stratified grey syenitic gneiss, consisting of grey felspar, bluish-white quartz and black hornblende. The weathered surfaces are rough and pitted. My barometers showed the head of Long Rapid to be eighty feet above the level of the river at Nolin's Island. A mile further on, a lagoon occurs on either side of the river. I afterwards learned from the Indians of the country that there is a portage from the lagoon on the north side to another channel of the Attawapishkat, nearly as large as the one we were ascending, and which falls into it only thirteen miles, in a straight line, below this portage.

Long Rapid.

Portage to N. channel.

At the next rapid, which is only a short distance above the lagoons, the ascent is fifteen feet. Here the river rushes over and among large angular masses of pinkish-grey granite, consisting of an even mixture of quartz, felspar and mica, with a medium or fine texture. The appearances indicate that this rock exists in place just beneath.

Granite.

The finer materials of the drift along this section of the river contain a large proportion of soft, yellowish limestone, but there is besides, a hard, bluish limestone, containing chert, which frequently occurs also as good sized boulders. In addition to these, among the more noticeable constituents of the drift of this region, may be mentioned the dark grey, finely quartziferous felsite or greywacké, resembling dark sandstone or friable quartzite in appearance, and holding rounded spots of a lighter color, weathering into pits of the same form, which is so generally and abundantly diffused in the drift all over the country, to the west and south-west of James' Bay. Hard reddish and brownish sandstones, impure jaspery iron ores and red jaspers, having the peculiar oolitic structure of those of the Manitounuck and Animikie series, may also be mentioned among the constituents of the drift along this part of the river.

Composition of of the drift.

Ascending the Attawapishkat from the last-mentioned rapid, we passed a dozen other rapids, alternating with small lake-like expanses, and at eleven miles, in a straight line from Nolin's Island, entered a direct south-westward continuation of the southwest arm of Attawapishkat Lake, but three or four feet below its level and separated from it by a short rapid, flowing out of the middle of the south side of the latter. The northern channel of the Attawapishkat River, above referred to, is said to discharge from the eastern extremity of this lake,

Attawapishkat Lake.

but this portion was not completely explored. Attawapishkat Lake is, however, apparently about nine miles long. Its inlet is near the west end.

Lake Lansdowne.

Still following up the river, for three miles from the inlet of the last mentioned lake, in which the rise amounts to only a few feet, we entered the largest sheet of water on the Attawapishkat, but strangely enough the Indians had no definite name for it. I, therefore, proposed to call it Lake Lansdowne, in honor of the Governor-General of the Dominion. As explained in my summary report, it was found to have a length of about thirteen miles, from south-east to north-west, and an extreme breadth of about ten miles. Lake Lansdowne is diversified by many beautiful islands, two of which measure about four miles each in length. The bays and points have all a north-east and south-west direction. A large, rounded, but not high hill, covered with second growth deciduous timber was seen in the western part of the lake, near the inlet or mouth of the upward continuation of the Attawapishkat River. The points and islands in the northern part of the lake are higher than elsewhere and have steep, wooded slopes, but they appear to be all composed of drift, and no rock *in situ* was seen anywhere around the lake. Long narrow moraines or rows of boulders extend south-westward off the extremities of some of the points and islands along the north-east side. Except where forest fires have run, large spruce and tamarac trees, and some cedars were observed on the islands and on the mainland near the lake, and also along the river between it and Nolin's Island. The mouth of the upper division of the Attawapishkat River, which the Indians described as a wide tranquil stream, is in the south-western bay of the lake. The Martin-drinking River, by which we should have travelled from the second highest of the Eabamet chain of lakes, enters a bay on the south side between the inlet and outlet. On the opposite side of the lake, a brook is reported by the local Indians to enter the first bay northward of the outlet; and by way of this stream, there is said to be a canoe-route to a lake on the Weenisk River, described as being as large as Lake Lansdowne, and called Wa-pi-quai-o Lake. Another canoe-route to the same lake was stated to begin in one of the northern bays of Lake Lansdowne, and a third route, which, however, strikes the Weenisk River above the lake referred to, was described as beginning in a bay a short distance south-west of the one last mentioned. Wa-pi-quai-o Lake would appear to correspond with "Weenisk" Lake of Arrowsmith's map, as the Indians stated that it receives a large stream from the west and discharges the Weenisk River to the north.

Lake Lansdowne.

Features.

Timber.

Routes to Weenisk River.

A triangular island, measuring about a mile and a half on each side, is formed at the outlet of Lake Lansdowne by a small channel north of the main discharge, by which we entered. In the bed of the southern channel, at a mile below the outlet, there is an exposure, at low water, of a grey, friable, "pepper and salt" gneiss, with a few reddish grains. The strike is S. 75° W., but the stratification is not conspicuous. Gneiss.

Below Nolin's Island, at the junction of Boulder River. the Attawapishkat flows eastward and is interrupted by three rapids in the first four miles. Its course then forms a semi-circle to the southward, four miles in diameter, and has marshy lagoons on either side. From the most south-easterly of these, a trail leads directly to Martin's Falls on the Albany. An intelligent Indian, who had just come from that trading port, informed me that the trail keeps the same bearing all the way, and on plotting it upon the map of my surveys of the two rivers, the position of the post is found to be directly in the line of this trail. The distance is about sixty miles, and the Indians report the country as level and covered with sphagnum. The trail is said to be crossed by five streams flowing into the Attawapishkat and only one into the Albany. From Nolin's Island downward. Trail to Martin's Falls.

At the termination of the above semi-circle, the channel we have been following joins the north branch from Attawapishkat Lake, the two branches here flowing towards each other from exactly opposite directions and meeting in the same line which bears about N.N.E. and S.S.W. The distance from the southern outlet of the lake to this junction is about twenty miles in a straight line. Channels join.

For thirty miles below this junction, the general course of the river is about east, and in this distance, it maintains a pretty uniform character, being alternately swift and rapid with long bends. The banks are of boulder-clay, ice-swept and sloping gently down from the brink to the summer level of the water, the whole height being about thirty feet. The surface of the country on both sides is low and level, as indeed it has been all the way from Lake Lansdowne. Except where the timber has been destroyed by fire, there is a good growth of spruce, tamarac, balsam, poplars and white birch along the banks of the river, but it does not extend far back, the country generally being open sphagnum swamps with small scattered tamarac and black spruce trees. Character of banks. Timber.

Three miles below the junction of the two channels, dark grey hornblendic gneiss is exposed on the south side. It is distinctly bedded and strikes N. 50° W. $< 90°$. Half a mile further down, grey, strongly banded or ribboned gneiss strikes with regularity, N. 60° W. At a strong rapid, thirteen miles below the junction, a considerable Gneiss.

area of fine-grained light reddish-grey contorted gneiss is exposed, the general strike of which is east and west. At nineteen miles below the junction, the river makes an "elbow" to the south-west and receives, at the angle, a large brook from that direction. On the south side, just below this brook, coarse grey gneiss is met with, striking from S. 40° to S. 60° W., but mostly in the latter direction, and dipping to the south-eastward at an angle of 40°. Two and a-half miles further down, similar gneiss has an average strike of S. 50° W., with a dip to the south-eastward. Knobs and hummocks of this rock continue in the channel and on the right bank for more than a mile farther. In the last eight miles of the above thirty miles stretch, the river divides itself among numerous alluvial islands, one group of which (ten or twelve in number), is about two miles in breadth. Another Indian trail to Martin's Falls leaves the river at the termination of this stretch. The distance is about fifty miles and the country traversed is described as a sphagnum swamp similar to that crossed by the trail to the same post which has been mentioned as leaving the Attawapishkat higher up. The old timber is still standing along the banks in some parts of the above section of the river, but as a rule, the forest consists of a second growth of poplars, white birch, spruce, tamarac and a little balsam. Here, as elsewhere, along this river, much of the timber has been killed by fires within the last few years and only bushes and young trees have yet replaced it. Small black ash trees have been noticed here and there, all the way from Lake Lansdowne to beyond the termination of the present stretch, and white cedars have been of frequent occurrence, except where the ground is unfavourable for their growth.

Alluvial islands.

Trail to Martin's Falls.

Timber.

At the termination of this thirty miles-stretch, the general course of the Attawapishkat changes to N.N.E., for about sixty miles, or to latitude 53° 0′ 0″, where a brook falls in from the left or west side. In the first nine miles of this distance, the river divides into two main channels, with several smaller ones, all flowing sluggishly through a level country between low alluvial banks. The place where they come together again is called Mattawa by the Indians and is a favourite burying-place for their dead. From Mattawa, the stream again becomes swift and rapid, as it was above these islands, and the banks resume their ice-swept bouldery and clayey character.

Course of river changes.

Mattawa.

At eight miles below Mattawa we passed the last exposure of Archæan rock on the river. At low water it forms a conspicuous island in the middle of the stream and consists of a strongly banded mottled grey gneissoid rock, but is composed of light-coloured felspar and black hornblende. The strike is straight and regular, N. 5° E. and the dip is eastward at an angle of 45°. It is cut by a dyke of the

Last exposure of Archæan rocks.

R. BELL, PHOTO.

IVES-PROCESS; G. E. DESBARATS, MONTREAL.

DEVONIAN LIMESTONES IN BANKS OF ATTAWAPISHKAT RIVER,

ABOUT 200 MILES FROM ITS OUTLET.—NATIVES IN FOREGROUND.

same composition, ten feet wide, bearing due north, with smaller dykes running in other directions. A dislocation was noted running S. 60° W., towards which the stratification bends in approaching it from either side. Several boulders of a reddish grey syenite were observed at this locality, which exactly resemble the syenite in the Huronian rocks of Shebandowan Lake.

Three miles below this rocky island, the river cuts through ridges of bouldery clay, capped with gravel, about 200 feet high, which here appear to run about north and south. From where the river enters these earthy ridges, its course is eastward for about four miles, after which it resumes the general north-north-east trend and flows with a smooth swift current, unbroken by rapids, such as are of frequent occurrence in the upper reaches, for twelve miles, between banks from twenty to forty feet high, composed of sandy and pebbly yellowish clay with some boulders. Ridges 200 feet high.

At the foot of an eastern "jog" in the river, about eleven miles further on, or sixteen miles in a straight line from the above mentioned island of gneissoid rock, unaltered limestone is seen in the right bank for the first time *in situ*. The strata are horizontal and consist partly of compact yellowish drab, rather thin beds, together with a larger proportion of porous and rusty looking layers, associated with iron-stained yellowish marl. The only fossils observed consist of large fucoids which cover the surfaces of some of the beds. Below this locality, yellowish limestones are exposed almost continuously in the banks or bed of the river for the next thirty-four miles. They often form cliffs from fifteen to thirty feet high, which are sometimes a mile or two long. Thick layers were observed in a few places. but, as a rule, the beds are thin. The strata appear to the eye to be quite horizontal, except in two localities where very local gentle undulations were observed. The river in this section is wide, shallow and swift. First horizontal limestone. Limestone cliffs.

In the above N.N.E. stretch of about sixty miles, the Attawapishkat receives no tributaries from the west that we could detect, except two or three small brooks, and the larger one at its termination, which has been already referred to. But it is joined by a considerable number of branches from the east in the same interval, the largest of which falls in at about forty miles down or eight miles below the first appearance of the horizontal limestone. The latitude of the mouth of this river, from the mean of two very closely agreeing observations is 52° 41′ 11″. A party of Indians of the country whom we met here had no name for this stream, and I propose to call it Streatfield River, after the Governor General's secretary. The accompanying illustration is from a photograph looking down-stream, which was taken opposite the mouth of this branch. It is a good representation of the Streatfield river.

character of the Atttawapiskat where it flows over the horizontal limestones.

Timber. Along the upper part of this stretch (of sixty miles) the timber is mostly green, and some of it is of fair size, but throughout the greater part of the distance the woods have been burnt at different periods many years ago, and, whether original forest or second growth, the trees are generally of small size. In some parts, spruce and tamarac are mixed with the poplars and white birch, but in others the coniferous and deciduous trees occupy separate areas. The sections of old timber and second-growth alternate at intervals of varying length with others more or less recently burnt and not yet reforested. The white cedar is scarce, but an occasional tree is found in favorable situations much further down the river. The last black ash observed on the Attawapishkat was passed in this section. An Indian from the Wai-nusk River, who was ascending this stretch, and who had never before been so far south, informed us that he had here seen the cedar for the first time in his life. He had not yet noticed the black ash, and had never even heard the Indian name of the tree.

Last black ash.

The next stretch of the river from the junction of the above mentioned brook, in latitude 53° 0′ 0″, bears E.N.E., and is about thirty miles long, terminating where the stream is joined by a very large branch from the west, called the Muckitat-michigan or Black Fence River, which, as far as could be seen, has the same general course as the united waters for some distance below. Tho horizontal limestone is exposed on both sides nearly all along the upper six miles of the stretch under description, but in the remainder of it the banks and bed of the river consist of drift, which is largely made up of the limestone debris. The country on both sides is level throughout this portion of the river. A large brook falls in from the south at six miles above the termination of this section.

Black Fence River.

Horizontal limestone.

Timber. The timber along both banks in the upper twelve miles of this reach consists of old green spruce of fair size, but in the remaining eighteen miles the green and recently burnt timber alternate in short sections. In some parts the fire was actually burning as we passed by.

The general course of the Attawapishkat, from the junction of the Black Fence River to its mouth, is about S. 70° E., and the distance in a straight line about 135 miles. The river has now become much larger, and it flows for many miles with a swift current between rather low banks of drift, the country on both sides being level. This latter character continues all the way to the sea. From this large branch to the mouth, the Attawapishkat is characterized by great numbers of islands. In the upper half of this long reach, only half-a-dozen tributaries were observed, and scarcely any at all in the lower

Stretch of 135 miles.

Many islands.

half, which may be due to the even nature of the surface of the country and its general and uniform slope to the eastward, thus causing the drainage to pass off in parallel lines direct to James' Bay.

Nineteen miles below the Black Fence River, the Missi-sagaigan, or Big Lake River, a good-sized stream, falls in from the south, opposite the upper part of an island three miles long. In the sandy banks, about the lower end of this island, marine shells were observed for the first time. The species collected are *Saxicava rugosa*, *Tellina Grœnlandica*, *Cardium Islandicum* and *Mya truncata*. The barometric readings would give this locality an elevation of about 500 feet above the sea. Horizontal beds of limestone occur in the bottom of the river, five miles above this point, and again at three miles below it, at the head of an island, which is over six miles long, and may be called Big Island. From the foot of Big Island, the river forms a semi-circle to the south, four miles in diameter, and then it divides into channels, which form four islands, with a total length of six miles. The water is shallow and the descent rapid in these channels, each of which is flanked by cliffs, about twenty feet high, of yellowish, crumbling, earthy limestone. This rock, and indeed all the limestones met with so far on this river, resemble those of the Churchill and the Kenogami Rivers, which are of Silurian age.

Big Lake River.

Marine shells.

Limestone cliffs.

Silurian age.

For the next twenty-three miles, the river flows southeast, and has upwards of twenty islands in this part of its course. On one of these, about a mile in length, occurring about the middle of this stretch, and which we called Rainy Island, the following fossils, as determined by Mr. Whiteaves, were collected in thinly-bedded limestone:

Favosites.—Species undeterminable. One fragment. Corallites about two inches in diameter; tabulæ complete.

Rainy Island fossils.

Strophomena.—Species undeterminable. One valve.

Euomphalus (or *Pleurotomaria*), nov. sp. Four casts of the interior of the shell.

Straparollus, allied to *S. Nevadensis*. One cast of the interior of the shell.

Fragments of two other species of gasteropoda.

Orthoceras, nov. sp. Four or five specimens of the siphuncle only.

Mr. Whiteaves considers these fossils to be of Devonian age.

Devonian age.

Throughout the above twenty-three miles, the river is generally wide and smooth, with low banks, composed of drift, while flat-bedded limestone is occasionally seen in the bottom. At the end of this distance, however, a sudden change takes place, and for thirty-three miles, or to the head of Lowasky Island (the general course being east) the river flows with a rapid current, between cliffs, and among almost innumerable islands of yellowish limestones, all having an

Limestone cliffs and islands.

Structure of limestone.

average height of about forty feet. These limestones have a singular structure. They consist of great, spongey and cavernous masses, often occupying the full height of the cliffs, which may be described as gigantic concretions, alternating with thinly-bedded portions, the lamination of which appears bent at all angles, to accommodate itself to the spaces between the concretionary portions. Close to the latter, the lamination often follows the contours of their outlines, but further away it dips at more moderate angles. The islets, which are thickly scattered among the larger islands in this part of the river, often appear to consist of single masses of this kind. Their surfaces, generally present a massive and very uneven, or rugged, appearance, but they sometimes show numerous patches of more or less concentric lines, marking a subordinate or internal, indistinct concretionary arrangement, or the edges of the thin beds, which have remained in basin-like forms, in the depressions on their exteriors. Both the massive and laminated varieties have a yellow or yellowish-grey color on fresh fracture, but the old surfaces have weathered to a blue or ash-grey. The accompanying sketches represent the appearances of the cliffs and islets in this part of the river.

Many islets.

The porous or cavernous masses are largely made up of fossils, although the number of species does not appear to be great, while the thinly-bedded inter-spaces contain but few. Mr. Whiteaves has determined the following from the specimens brought home, and he considers them to indicate the Devonian system:—

Devonian fossils.

Favosites, species undeterminable. One fragment. Corallites polygonal; their maximum diameter five mm.; tabulæ complete, arched and crowded.

Meristella (*Whitefieldia*), nov. sp. allied to *Whitefieldia tumida*, Dalman (sp.) and *W. nasuta*, Conrad.

Strophodonta, species uncertain, but allied to *S. concava* or *S. ampla*.

Long cylindrical corals, like *Amplexus* or *Zaphrentis*, and a large trilobite, apparently allied to *Bronteus*, but resembling *Proetus* in the broad outer margin of the pygidium, were also observed, but owing to the friable nature of the rock, specimens for identification could not be obtained. The numerous caverns, often of fantastic shape, but seldom of very large size, in the cliffs and islets of this part of the river, give the scenery a very singular and picturesque character. The Indians from the Equan River (the next large stream north of the Attawapishkat) report similar light-coloured, cavernous rocks, along the lower portion of its course.

Caverns.

Equan River.

At forty-four miles before coming to its mouth, the Attawapishkat divides into two channels. We followed the southern or smaller of them, which is called Lowasky River on Arrowsmith's map, and the

Lowasky River.

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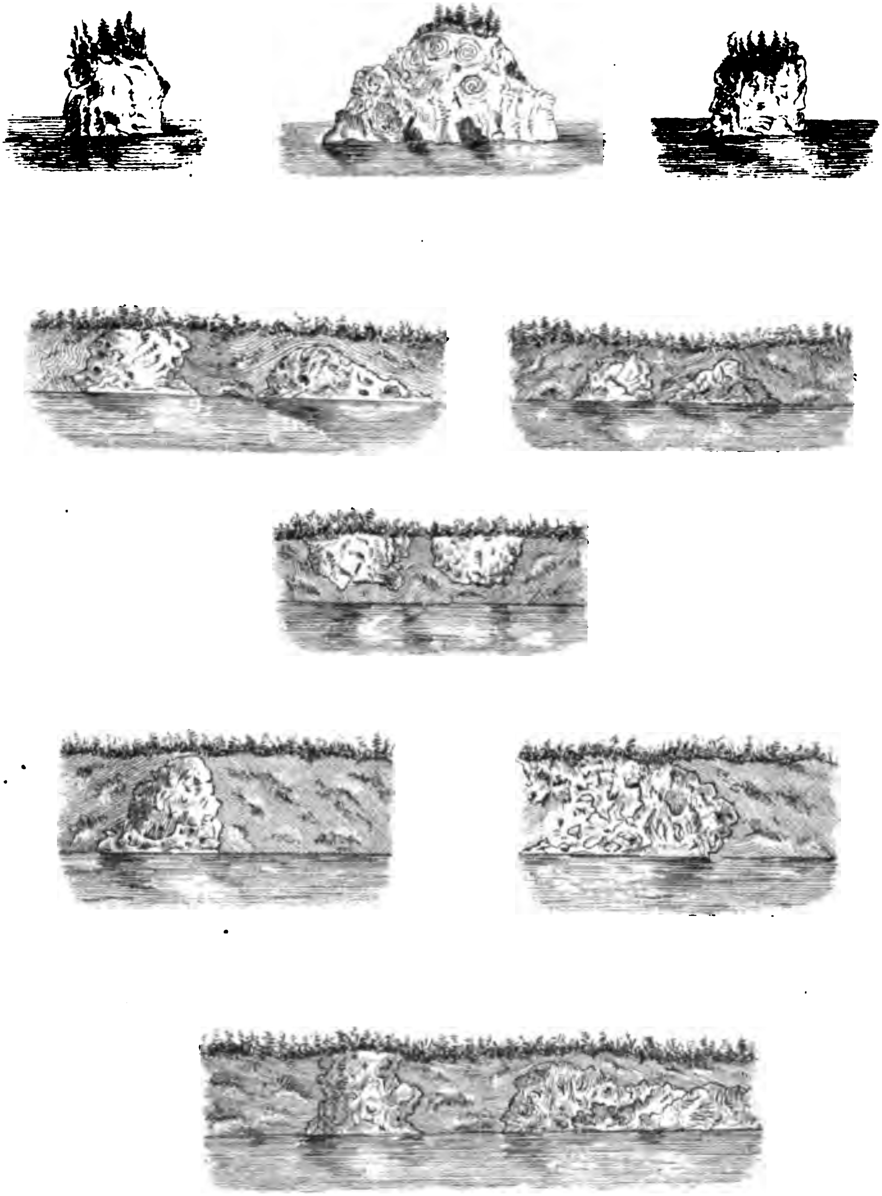

CAVERNOUS LIMESTONE ON ATTAWAPISHKAT RIVER.

From Sketches by Dr. R. Bell.

island between it and the northern or larger channel, which has the above length (44 miles) may be called Lowasky Island. The limestones above described extend for a few miles down the southern branch, and there may be small channels in this neighborhood between the two branches, but in the rest of its course the Lowasky River presented little requiring description. The banks, which are generally low, consist of bouldery clay, with stratified gravel or loam occasionally at the top. Numerous shallow rapids occur. The tide extends to the foot of three such rapids, close together, about eleven miles from the mouth. A channel, which appeared to be a feeder, but which may be a discharge, occurs at four miles from James' Bay. In the marshes on either side of the mouth of the river, we observed great numbers of geese and ducks as we passed out to sea, on the 7th of September.

Tide.

Marshes.

Throughout the long stretch from Black Fence River to the sea, the country on both sides maintains the same level and swampy character which has been described as prevailing higher up. The timber on the borders of the river, where still green, is smaller along this section than along the upper parts. Some portions, consisting principally of spruce and tamarac, appear to belong to the original forest, but much of it is no doubt second-growth, and these two species are then usually mixed with poplars and some small white birch. The growing timber, whether original or second-growth, is not often continuous for any great distance, being interrupted nearly the whole way by frequent sections of burnt ground.

Level and swampy.

Timber.

From the barometric readings obtained on Lake Lansdowne, this sheet of water would appear to be about 960 feet above the sea, which shows that the general fall in the surface of the country between it and James' Bay must be very gradual indeed. It is a remarkable fact that we did not require to make a single portage in the whole distance from this lake to the sea, and I could hear of no portages in the continuation of the river above the lake. The Indians describe the latter as a wide and tranquil stream, expanding into several lakes along its course.

Level of Lake Lansdowne.

No portages.

Sturgeon are abundant in the lakes of the Attawapishkat, and they appear to constitute the principal food of the few Indians who inhabit the country. Whitefish are also caught both in the lakes and along the river itself. Pike and suckers are abundant in all the waters. The Canada goose breeds in considerable numbers in the open swamps behind the wooded borders of the lower section of the river, and the young birds, ready to fly, were congregating in flocks, all along the lower stretch, in the end of August and the beginning of September. The dusky and other species of ducks were also numerous, and the yellow-legged plover was very abundant. We saw a few cariboo and several black bears while descending the lower part of the river.

Fishes.

Birds.

Indians.

The Indians of the Attawapishkat and Weenisk districts appear to have diminished greatly in numbers since the last sixty or seventy years. At that time several trading posts were maintained in this territory, where none now exist. We met with only a few families, but a good many Indian graves were noticed along the banks of the river. Those living far up the stream never go to the sea. One old man with whom we talked had never been at any trading post. Few of them had ever seen a white man before. One young man whom we fell in with on Attawapishkat Lake accompanied us up to Lake Lansdowne, and after a few days' acquaintance, I had no difficulty in engaging him to go with us to James' Bay, and thence up the Albany, from which he was to cross by one of the Martin's Falls trails to his own river again.

Kapushkow River.

After leaving the southern mouth of the Attawapishkat, we reached the Kapushkow River in our canoes in three hours and a half, the distance being only about ten miles. Starting from this river early next morning (8th September), we ran the whole distance to Fort Albany the same day, by sailing and paddling, arriving there late in the evening. The shore of James' Bay between the two rivers is extremely low. The beach along high-water mark is sandy and marshy, but when the tide is out, reefs of boulders and stones, which look interminable, stretch out to sea as far as the eye can reach. The tide had fallen some time before we approached the Albany River, and in order to get past these reefs in our canoes we were obliged to go so far out to sea that the tops of the trees on the nearest part of the shore were barely visible at a few points. Even at high water, it requires an experienced pilot to take a sail-boat over these extensive bouldery reefs. We were told that the water is so shallow that no large vessel could pass between the west shore of James' Bay and "Agoomska" Island. This large island lies nearer to the west shore of the bay than is represented on the maps, and it is called by the Indians of the region Agimiski or Akimiski.

Fort Albany.

Low shore.

Bouldery reefs.

Akimiski Island.

Albany River.

Mouth of Albany River.

Where the Albany River flows into James' Bay, the coast is as low as possible, the water in front very shallow, and the country inland level and swampy. As the water of the bay is receding rapidly (in a geological sense), it becomes difficult to draw the line between the sea and what may be considered land. Fort Albany, one of the oldest and largest trading posts of the Hudson's Bay Company, is built on the south side of an island of the same name, six miles long and two and a-half wide, lying just inside the present mouth of the river. The channels on either side are of about equal size. Below it are two islands

Albany Island.

of sand and mud, covered with grass, sedges and bushes, but Albany Island is the first one which is timbered. As the mouth of the river and the adjacent shores are so difficult to define, all measurements of distances in the following description of the river will be taken from the Fort itself, which is situated about seven miles in, from the general line of the present mean high tide mark. Tide-water extends for only about three miles above the Fort. Tide-water.

As stated in a previous part of this report, in 1871 I made a micrometer and compass survey, with numerous latitudes, of the Albany from Abazotikitchewan Lake downwards to The Forks, or junction of the Kenogami or Long Lake River, and thence up this river and via Long Lake and Pic River to Lake Superior. A track-survey having been made the present season of the upper part of the Albany, from Lake St. Joseph to Abazotikitchewan Lake, the lower section of the river, extending from the mouth to The Forks, was all that remained to complete the survey of the whole stream. It was only possible with the time and means at my disposal to make a track-survey of this part, on our return journey last autumn, but this was done with great care, and having ascertained the latitude and the variation of the compass in numerous places, I think the resulting map will prove very nearly correct. Micrometer survey. Track-survey.

In size, the Albany is comparable with the Ottawa, and at high water it might be navigated by powerful river steamers from the mouth to Martin's Falls, where the first portage occurs, a distance of about 250 miles, following the general trend of the river. Its upward course, from Fort Albany to The Forks, bears about S. 45° W. (true) and the distance, in a straight line, is about 131 miles. For sixteen miles above the Fort, the river is wide, between the main shores, and full of islands of various sizes, and although the descent in the above distance is rapid, this portion may be called its delta. The channels spread widely over the flat-lying Devonian limestones, and the Lower and Upper Big "Falls," the strongest rapids below Martin's Falls, occur in this part. Big Island, which is the largest of this group, is six miles long. At thirteen miles from the Fort, a channel leaves the main river on the north side, and flows directly to the sea, falling into it several miles northward of Albany Island. Size of Albany River. Islands near mouth.

For nearly twenty miles above the head of the delta, the river flows in a single channel free from islands, but from thence upward to The Forks, a considerable number are met with. The largest of them are Fishing Creek (five miles long), Black Bear (seven miles), Norran's and Chee-pye Islands. Large islands.

Some rivers and numerous brooks fall into the Albany below The Forks, from the swampy country on either side. The larger tributaries Branches.

are Lower Fishing Creek from the south, almost opposite Fort Albany, Upper Fishing Creek, from the north, at about one-third the distance to The Forks, and two other large brooks from the same side a few miles below it; Chemahogan River, from the south, at two-thirds of this distance, and the Chee-pye River, eight miles farther down. The latter is the largest branch below the Kenogami. The Henley River falls in from the north, ten miles below The Forks. Henley House, a former Hudson's Bay Company's post, was built on a gravelly island, which is now being swept away. at the north of this stream. Several lakes, abounding in fish, are said to occur on the course of this river.

Henley River.

From The Forks all the way down to the delta, the Albany flows in long sweeping curves, with a pretty uniform current, broken by occasional rapids. The elevation of The Forks, from barometric observations, is about 300 feet over the sea, which would give an average fall of about two feet in the mile, following the course of the stream. In two of the stretches, known as the "Long Openings," the river is so straight that, sitting in a canoe and looking from one end of them, the sky and water appear to meet on the horizon.

Rate of fall.

Flat country.

The country on either side is quite flat, and behind the strips of forest, which extend to a varying breadth from the banks of the river, it is covered with sphagnum, with only stunted tamaracs and black spruces at wide intervals. In some parts, it is so open as to be called "plains," and on these the cariboo are found occasionally in considerable numbers, especially during the winter.

Plains.

Character of banks.

Bluffs of stoney clay, fifty feet or more in height occur along some sections, but, as a rule, the banks are lower. Both sides are completely ice-swept throughout the entire length of this stretch. There is often a cut-bank a few feet high at the top, but from the foot of this, the wide shore slopes gradually down to the low-water level. The upper portion of this slope, comprising the greater part of its breadth, is paved with boulders and worn stones, all crowded closely together and forced down to an even surface by the repeated moving pressure of the river ice as it is carried rapidly along during the spring freshets. The rise and fall of the river between high and low-water marks would appear to average nearly thirty feet, but where temporaray ice-jams have occurred, it sometimes exceeds this. The Indians say that it rarely overflows any of the country beyond the banks.

Devonian limestones.

Thin horizontal beds of light yellowish-grey limestone, of Devonian age, begin at the first rapid, about three miles from Fort Albany and are exposed almost continuously in the bed of the river for several miles above. The descent in the stream is so rapid that the thickness of the level strata over which it falls, must amount to, at least, twenty

R. BELL, PHOTO., 1886. IVES-PROCESS ; G. E. DESBARATS & SON, MONTREAL.

ALBANY RIVER, FIVE MILES BELOW THE FORKS:
SHOWING ICE-SWEPT SHORES: "PAVEMENTS."

or thirty feet in this part of the river. Flat beds of similar limestone were seen here and there, sometimes covering considerable areas in the bed of the river, but rarely in the banks, to within about fifteen miles below The Forks. From this circumstance and owing to the level and undisturbed nature of the country, as well as from the abundance of angular fragments of Devonian limestone in the drift all along, there is no doubt that the Albany flows over flat-lying strata of this system, from the point above named to its mouth. The following is Mr. Whiteaves' list of the fossils collected in the above section of the Albany:

Syringopora Hisingeri, Billings. One small fragment. List of fossils.

Heliophyllum Canadense, Billings. One small but nearly perfect specimen and two fragments.

Favosites hemispherica, Yandell and Shumard. One fragment. Corallites one mm. in diameter: tabulæ complete.

Favosites, species indeterminable. Fragments. Epitheca thick and strongly developed: corallites two mm. broad: tabulæ complete.

Dictyonema, species indeterminable. One specimen.

Ptilodictya Gilberti, Meek, var. One specimen which resembles Meek's species in its microscopical characters, but in which the frond is apparently undivided.

Strophomena rhomboidalis, Wilckens. One well-preserved and nearly perfect specimen of each valve.

Strophodonta demissa, Conrad. Four ventral valves.

S. Patersoni? Hall. One fragment.

S. concava? Hall. An exfoliated cast of a ventral valve.

Orthis, species indeterminable. One specimen.

Spirifera, two or three species. Fragments only.

Meristella, nov. sp., allied to *M. unisulcata*, Conrad.

Atrypa reticularis, L. Two specimens.

Centronella glans-fagea, Hall. One perfect specimen.

Conocardium trigonale, Conrad. Two specimens.

Proetus crassimarginatus, Hall. One pygidium.

Mr. Whiteaves remarks that the above fossils "are clearly of Devonian and probably of Lower Devonian age."

Beginning at about fifteen miles below The Forks and extending thence for some miles up-stream, yellowish limestones, some of the beds being of a very spongy or finely vesicular character, are exposed at a few places along the north-west shore of the river. These limestones may belong to the Upper Silurian System, like those higher up the Albany and also on the Kenogami. (See Geol. Survey Report for 1871.) Supposed Silurian.

Post Pliocene shells.

Marine shells of Post Pliocene age, washed from the river banks, were observed in many places all the way from the sea to The Forks. They were abundant in a modified grey clay in the north-west bank, from Cap Island, thirty miles below The Forks, for a number of miles upward. The following species were collected in this section: *Tellina Grœnlandica*, *T. proxima*, *Saxicava rugosa* (valves closed), *Cardium Grœnlandicum*, *Mya truncata* (with the epidermis), *Astarte Laurentiana*.

Timber.

Forest fires have destroyed much of the timber along the banks of the part of the Albany now under description. Old spruces and tamaracs of good size are still green in some sections, but second-growth timber, much of it well grown up, prevails for the greater part of its length. A good deal of both kinds have been only recently burnt. In addition to the spruce and tamarac, balsam, aspen, rough-barked poplar and white birch occur all along. Banksian pine and ground maple were observed in the upper part. White cedar was first seen about twenty miles below The Forks. Grey elm and black ash were noted on the Kenogami just after we left the Albany or some distance further north than they were observed when surveying this river in 1871. Groves of both these kinds of trees are found on the alluvial flats at the mouths of all the branches of the Kenogami. Cedar of good size is common all along the banks of this stream. It may be remarked that the occurrence, or otherwise, of certain trees along a river like the Albany may be due to the nature of the ground as much as to latitude.

Cedar, elm and ash.

Kenogami River and Long Lake.

The Kenogami River and Long Lake were surveyed and reported upon in 1870 and 1871, and nothing requiring special description in this place was observed on our homeward journey, with the exception of some facts as to the drift, which will be mentioned further on.

Black River.

The rocks along the Black River, by which we travelled from Long Lake to the Canadian Pacific Railway line, as stated in my summary report, were found to consist of crystalline schists and diorite, granite, syenite and gneiss, but further exploration will be required in this region before anything definite can be said as to their distribution.

Courses of glacial striæ.

LIST, SHOWING THE COURSES OF THE GLACIAL STRIÆ IN THIRTY-FIVE LOCALITIES IN THE REGION EXPLORED IN 1886.

The glacial striæ were carefully looked for wherever the solid rock was exposed, and their course was recorded in all cases where it could be distinctly seen. Exceptional instances, such as those on nearly vertical walls of rock, or on very uneven surfaces, are omitted from the following list. The bearings refer to the magnetic meridian, but the differences between them and the true bearings are not great, as the line of no variation passes through the central part of the region which they cover.

1.	Minnietakie Lake, 8 miles from S. W. extremity	S. 45° W.
2.	do. 3 miles S. of Abram's Chute, at the outlet	S. 40° W.
3.	Abram's Chute	S. 10° W.
4.	Islands in the middle of Abram's Lake (below Chute)	S. 40° W.
5.	Island in Lonely Lake, 10 miles due east of H. B. Co.'s post	S. 60° W.
6.	Point in Lonely Lake, 13 miles eastward of H. B. Co.'s post	S. 25° W.
7.	Point on N. shore of Lonely Lake, 16 miles eastward of H. B. Co.'s post	S. 55° W.
8.	Rapid at mouth of Root River, E. extremity of Lonely Lake	S. 45° W.
9.	Root River, 5 miles in a straight line from its mouth	S. 50° W.
10.	Root River, 10 miles in a straight line from its mouth	S. 45° W.
11.	N. side of L. St. Joseph, 4½ miles from W. extremity	S. 30° W.
12.	Western mouth of Cat River, 9 miles from W. extremity	S. 45° W.
13.	Island in Lake St. Joseph, 18 miles from W. extremity	S. 60° W.
14.	Islet in Lake St. Joseph, 4 miles E. of E. mouth of Cat River	S. 15° W.
15.	Islet in Lake St. Joseph, 7 miles E. by S. of mouth of Cat River	S. 45° W.
16.	Fall Fishery on N. shore of L. St. J., 44 miles from W. end	S. 30° W.
17.	Extremity of N. arm of Lake St. J., 50 miles from W. end	S. 30° W.
18.	Northern outlet of Deer Lodge Lake, on the Albany River, 13 miles below Lake St. Joseph	S. 20° W.
19.	First Kagami Portage, Albany R., 22 miles below Lake St. J	S. 40° W.
20.	Albany River, 2½ miles below Etow-i-ma-mi Branch	S. 25° W.
21.	Narrows about middle of Maminiska Lake	S. 65° W.
22.	Middle of Patawonga Lake	S. 75° W.
23.	Outlet of Eabamet Lake	S. 80° W.
24.	North shore and also head of Eabamet Lake	S. 75° W.
25.	Inlet of Sturgeon Lake, Boulder River	S. 70° W.
26.	Attawapishkat River, 3 miles below junction of the two channels from lake of the same name	S. 60° W.
27.	Attawapishkat River, 13 miles below the above junction	S. 42° W.
28.	do. 22 miles below the above junction	S. 22° W.
29.	do. 23 miles below the above junction	S. 15° W.
30.	do. Last exposure of Archæan rocks, or 8 miles below Mattawa	S. to S. 10° E.
31.	Attawapishkat River (on limestone), about 75 miles from southern mouth of river	S. 18° W.
32.	Attawapishkat River (on limestone), about 66 miles from southern mouth of river	S. 8° to 12° W. (Old set.) S. 60° to 70° E. (New set.)
33.	Attawapishkat River (on limestone), at head of Lowasky Island, about 44 miles from southern mouth of river	S. 02° W.
34.	Attawapishkat River, southern channel or Lowasky River, about 40 miles from southern mouth of river	S. 35° W. Older, all round to S. 80° W., newer.

(At this locality the striæ are newer in proportion as they become more westerly.)

35.	Kenogami River, 8th Portage (in going up), about 20 miles below Pine Lake	S. 40° W.

General direction. From the foregoing list it will be observed that the general direction of the glacial striæ is to the south-westward, as it is elsewhere throughout the great Laurentian region between James' Bay, Lake Winnipeg and Lake Superior. In descending from the Laurentian plateau along the Attawapishkat River the course of the striation becomes more and more southerly, but on the horizontal limestones further down the stream it runs in various directions between west and south at the same localities.

Drift deposits. The drift (principally boulder-clay) which overspreads the palæozoic basin westward of James' Bay appears to be a continuous sheet varying probably between thirty and ninety feet as far as can be judged by the sections along the rivers. Over the generally level surface of the Laurentian rocks further west, the thickness is more variable, but it seldom appears to exceed 100 feet, and it becomes thinner and more irregular as we rise higher and get further inland, and in these regions the fundamental rocks protrude themselves more frequently through it. It is of a looser and less clayey nature on the higher grounds than elsewhere, and consists largely of washed gravel and shingle.

Remarkable features. Along the Attawapishkat, Albany and Kenogami Rivers, as well as on the west coast of James' Bay, the most remarkable feature in the composition of the drift is the abundance of pebbles and boulders of dark grey granular siliceous felsite or greywacké. It constitutes the greater number of the boulders and pebbles of the extensive reefs which have been referred to, between Akimiski Island and the west shore, and is abundant among the boulders of the coast between Rupert's House and Moose Factory. Well-rounded fragments of this rock are also found along the Moose and Missinaibi Rivers, and as far west as Lonely Lake, and southward to Lake Superior. It is characterized by round spots, from the size of a pea to that of a cricket ball or larger, of a lighter colour than the rest of the rock, which weather out into pits of the same form. Microscopic sections show that it is composed principally of small angular grains of felspar with others, somewhat rounded, of quartz, the interspaces being filled in with a dark green amorphous mineral. This rock occurs *in situ* on Long Island, off Cape Jones, on the east main coast, where it strikes south-westward or with the greater length of the island. The same rock, no doubt, continues under the sea for some distance in the direction of its strike. The abundance

Hæmatite in drift. also of rounded pieces of hard, banded, siliceous hæmatite in the drift of both the Attawapishkat and Albany Rivers is another striking feature which was alluded to in reference to the latter in 1871. (Geol. Survey Report for 1871, page 112.)

Composition of the drift. After careful observations as to the nature of the drift along the rivers mentioned, the following appears to be about the relative abun-

dance of its boulders and pebbles: the unaltered limestones which occur *in situ* immediately beneath; the dark grey siliceous greywacké above described; compact hard blue limestone; gneiss syenite and granite; crystalline dark, grey and mottled and porphyritic diorites; slaty and jaspery banded hæmatites, compact siliceous magnetites, sometimes consisting of pure ore and fine-grained quartzite in thin alternate layers; quartzites of different shades; hard red sandstones and conglomerates; chloritic and hornblendic schists; dull red jaspers with oolitic structure like those of the Manitounuck or the Animikie series, or mixed with streaks and small disseminated spots of the peroxides of iron; compact amygdaloids; brecciated hard blue limestone; drab-coloured clay ironstone.

Extent of palæozoic rocks.

From our present knowledge of the distribution of the flat-lying palæozoic rocks west and south-west of James' Bay, it is pretty certain that they occupy an area as extensive as the whole region between the Ottawa River and Lakes Ontario, Erie and Huron. The contours of the outer margins of this basin, as well as those of the different horizons within it, as far as they have yet been determined, indicate that its geological centre or highest point is under James' Bay, off the mouth of the Albany River. In such an extensive and undisturbed basin, the occurrence of Carboniferous rocks might appear possible, and if they existed at all it would probably be near this centre. But the total absence of any trace of them in the drift which has come from that direction, and spread itself over the extensive region alluded to, leaves very little hope of finding such rocks in this part of the Dominion. The Devonian rocks no doubt underlie a great part of James' Bay, and they probably occupy a still greater area of the extraordinarily level bottom of the main body of Hudson's Bay itself, and here there would be a greater probability of the occurrence of Carboniferous rocks than in James' Bay. Yet no evidence of their existence has so far been afforded by the drift of the shores of the larger bay, or in any part of the surrounding country which has been examined.

Absence of Carboniferous rocks.

Source of the drift.

Judging from the approximate distribution of the rocks in Hudson's and James' Bays, and the courses which were probably followed by the drift, as indicated by the glacial striation all around these bays and in the great interior regions to the south-west of them, the drift of the country to the west and south-west of James' Bay would be derived from the bottom and east side of this bay, or it may have partly come originally from the site of Hudson's Bay, and thence been transported over the floor of James' Bay to the country referred to.

On the Kenogami, at six miles by the stream above the mouth of the large southern branch called the Bagutchewan, the river makes a

sudden bend to the north, and about a mile further another similar bend. These unusually sharp curves, which are unlike any others in the course of the stream, appear to be caused by the river traversing pre-glacial excavations in the Silurian strata, which here consist of dull-red, coarse, somewhat indurated arenaceous marl, with green blotches and layers. These excavations had become filled up with loose materials before the formation of the present river channel. At the lower bend, gravel fifty feet deep is exposed in the south bank. At the upper bend, the excavation of the Silurian marls is plainly seen. Starting from the level of the river, the lower ten feet of the filling of this hollow consists of boulder-clay. Upon this rests a bed, six to eight feet thick, of soft lignite, containing many flattened stems of small trees, which are partially carbonized, but are somewhat elastic when newly excavated and still wet. The lignite bed is overlain by thirty or forty feet of rudely stratified red and grey drift, holding rounded boulders and many pebbles. Marine shells were observed in the drift along the Kenogami almost up to this point, which, according to my barometric readings, would have an elevation of about 500 feet above the sea.

Pre-glacial excavations.

Lignite.

Marine shells.

Acknowledgement.

Before concluding this report, I wish to acknowledge our usual indebtedness to the officers of the Hudson's Bay Company for personal courtesies or assistance in promoting the objects of our survey. I would mention the following gentlemen who aided us during the past season:—Messrs. Chief Commissioner Wrigley, Newton Flannigan, Alexander Matheson, John Hourston, R. C. Wilson, William Mackay and Isaac Hunter.

APPENDIX I.

List of Lepidoptera collected in the Southern Part of Keewatin District.

By Dr. R. Bell.

The following Lepidoptera were collected in 1883 while exploring the country from Wabigoon Lake to Red Lake, by way of Lonely Lake, which adjoins on the west that explored in 1886. The species were determined by Major H. H. Lyman of Montreal, with the exception of the last two, which were named by the Rev. George D. Hulst of Brooklyn, at Major Lyman's request:—

1. *Pieris napi*, Esper., var. *oleracea-æstiva*, Harris.
2. *Argynnis polaris*, Boisd.
3. *Grapta Progne*, Cram.
4. *Limenitis Arthemis*, Drury.
5. *Pamphila metacomet*, Harris.
6. *Callimorpha Lecontei*, Boisd.
7. *Euprepia Americana*, Harris.
8. *Apamea nictitans*, Bkh.
9. *Heliophila pallens*, Linn.
10. *Chærodes transversata*, Drury.
11. *Metrocampa margaritata*, Linn., var. *perlata*, Guen.
12. *Sicya macularia*, Harris.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE GEOLOGY OF A PORTION

OF THE

EASTERN TOWNSHIPS

RELATING MORE ESPECIALLY TO THE

COUNTIES OF COMPTON, STANSTEAD, BEAUCE, RICHMOND AND WOLFE.

BY

R. W. ELLS, LL.D.

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ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., etc..

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to submit herewith my report on the work of the past two seasons, 1885 and 1886, on the geology of a portion of the Eastern Townships of Quebec.

The accompanying map is the south-eastern quarter-sheet of that known as the map of the Eastern Townships, compiled by the late Mr. R. Barlow, and first engraved in 1868, but hitherto published only as a topographical map. Although many additional surveys have been made since that date, in several of the townships embraced in the quarter-sheet, these have not all been incorporated in full, since, while not affording much assistance in the interpretation of the geology, it is found that such a course would further delay the present publication.

I have the honor to be,

Sir,

Your obedient servant,

R. W. ELLS.

Ottawa, April 12th, 1887.

REPORT

ON THE GEOLOGY OF A PORTION

OF THE

EASTERN TOWNSHIPS OF QUEBEC,

RELATING MORE ESPECIALLY TO THE

COUNTIES OF COMPTON, STANSTEAD, BEAUCE, RICHMOND AND WOLFE.

BY

R. W. ELLS, LL.D.

The present report embraces the results of the work of the past two seasons, devoted to the revision and completion of the geological survey of that part of the province of Quebec, shown in the south-eastern quarter-sheet of the map of the Eastern Townships. Great progress has been made in the development of this portion of the province during the last twenty years, evidenced by the construction of the several lines of railway which centre in the city of Sherbrooke, as well as by the opening of hundreds of miles of settlement roads, by which large areas, formerly inaccessible, have now become comparatively open to investigation. Greatly increased facilities for the study of the geological structure of the district, are in consequence afforded.

Work of former years. A large amount of exploratory work had been done in former years by various members of the Survey staff. Among these may be mentioned the late Sir Wm. E. Logan, Dr. T. Sterry Hunt, Dr. Selwyn, Messrs. Richardson, Weston, Webster, and Brown; and various reports, having a bearing on the geology and mineral wealth of this section of country, have appeared from time to time. The principal of these, published by the Survey, are:—

Reports bearing on the subject.

Sir W. E. Logan—1847-48—On the Geology of portions of Lower Canada, more especially of the Eastern Townships.
" 1849-50—On the Geology of Lower Canada south of the St. Lawrence.
" 1850-51—On the Gold of the Chaudière Valley.
" 1863—Geology of Canada, the Quebec Group, etc.

Mr. A. Michel—1863-66—On the Gold Region of Lower Canada.

Dr. T. Sterry Hunt—1863-66—On Gold Assays of Quartz from Eastern Canada.

Mr. Jas. Richardson—1863-66—On the Geology of the Quebec Group in the Eastern Townships.

Dr. A. R. C. Selwyn—1870-71—Notes and Observations on the Gold-fields of Quebec and Nova Scotia.
" 1877-78—Observations on the Stratigraphy of the Quebec Group and the older Crystalline Rocks of Canada.
" 1880-81-82—Notes on the Geology of the South-eastern Portion of the Province of Quebec.
" 1882—The Quebec Group in Geology.—Trans. Royal Soc. Canada. Vol. I.
" 1884—Descriptive Sketch of the Physical Geography and Geology of the Dominion of Canada. Part I.

Mr. Frank D. Adams—1880-81-82—Notes on the Microscopic Structure of some Rocks of the Quebec Group.

Among other papers bearing on the subject may be mentioned:—

Mr. G. F. Matthew—1865—Geology of Southern New Brunswick, Cupriferous Rocks of South-eastern New Brunswick, compared with those of the Eastern Townships of Canada.

Prof. H. Y. Hind, 1865—Geology of New Brunswick; the Quebec Group.

Dr. T. Sterry Hunt—1878—Second Geological Survey of Pennsylvania; A History of the Taconic and Quebec Group Controversy.

Sir Wm. Dawson—1883—Appendix to Life of Sir W. E. Logan; the Quebec Group.

Dr. Selwyn—1883—Review of the same.

A review of the various reports above enumerated would, no doubt, be interesting, but is to a great extent rendered unnecessary in this place, since the history of the Quebec group, with the several opinions held from time to time regarding the geological position of its several divisions, has already been given in part by Dr. T. Sterry Hunt.

Topographical work done.

In order to fix more precisely the limits of the different formations, as well as to render the map more complete, a large amount of topographical work was necessary. It has not been possible in the time at our disposal to add all the new surveys made since the engraving of the map in 1868, but enough has been done, it is hoped, to enable us to present an intelligent view of the complicated structure which prevails over much of the area in question. I have been assisted in this work throughout by Mr. N. J. Giroux, C.E., P.L.S.

From our examinations, as well as from those of previous observers in this field, the following geological systems have been recognized :— Systems recognized.

E. Silurian.
D. Cambro-Silurian.
C. Cambrian.
A. B. Pre-Cambrian.
Crystalline and igneous rocks, volcanic and plutonic.

E. Silurian.

By reference to the Geology of Canada, 1863, and to the large geological map, 1866, it will be seen that a very considerable portion of the area of the accompanying map was then supposed to be occupied by rocks of this age. They were held to cover a great part of the counties of Beauce, Richmond, Wolfe, Stanstead, Compton and Sherbrooke. The earliest examination of the area by the Geological Survey was made in a hasty traverse by Sir Wm. E. Logan, in 1847, the results of which are given in his Report for 1847-48. This related more particularly to the area lying east of a line extending from the head of the east bay (Fitch Bay) of Lake Memphremagog to the mouth of the Famine River, on the Chaudière. The characters of the various rocks seen in this section are there clearly stated, while their age was inferred to be Silurian, or in part Devonian, on the supposition that they formed the westward prolongation of the members of these systems as recognized in the Gaspé peninsula. Early work of Sir W. E. Logan, 1847.

All these rocks were supposed to be closely related, but were divided into two formations, the one highly calcareous, the other apparently devoid of limestone. The first or calcareous formation was stated to have a breadth of about twenty miles, and to be composed of arenaceous and micaceous limestones, which are at times crystalline, interstratified with fine and coarse mica-slates. It was further stated that on a line of section drawn from the metamorphic ridge of the Massawippi Mountain east to Canaan, the limestone was much more abundant in the first three miles than in the remaining distance, and was usually of a dark color, sometimes approaching a dull, earthy black, and frequently separated by thin, black carbonaceous shales, having a satiny lustre on fresh fracture, resulting probably from the presence of very fine scales of mica, the former weathering often to a deep brown, and the slates to a brownish-black. Other varieties of limestone are grey, striped, banded and white. They frequently contain a considerable quantity of iron-pyrites, disseminated in cubes up to nearly an inch in size. The fossiliferous character of these rocks, First views as to the structure. Section between Massawippi Mountain and Canaan.

more particularly as displayed at Dudswell and around the shores of Lake Memphremagog, was pointed out by Sir Wm. Logan. The fossils differ considerably at various points. The Dudswell rock contains immense quantities of corals, often of large size, together with crinoids; while at Georgeville and Potton Ferry, now Knowlton's Landing, in Sargent's Bay, calcareous strata are found, which, while containing somewhat similar organic remains, appear as a whole to belong to a later period. A limited outcrop at Magoon's Point was recognized by Sir Wm. Logan as fossiliferous, only by the presence of small crinoid stems. Closely allied forms were also observed in an outcrop of limestone on the north-east side of the Chaudière River, mid-way between the Famine River and the village of St. George, Beauce, in which brachiopod shells are also abundant. All these fossiliferous beds were at that time supposed to represent the lower portion of the calcareous formation.

Localities for fossils.

Returning to the line of section between Fitch Bay and Canaan, the mica-slates, which are interstratified with the calcareous beds in the first three miles of the section mentioned, are usually soft and fine, resembling clay-slates with addition of mica. But in the remaining seventeen miles of the first portion, this calcareous character is less marked, the rocks becoming coarser and more quartzose, though beds of impure siliceous limestone still occur at intervals as far as Lot 6, R. VIII., Barford. Black slaty beds, displaying crystals of chiastolite, appear in places. The whole formation is highly pyritous, and the beds have a very uniform dip to the north-west for the greater part of the distance. Many corrugations or folds doubtless occur, by which the calcareous or other beds are brought to the surface at various points.

Section between Fitch Bay and Canaan.

From the locality noted above in Barford to Canaan, a distance of about twelve miles, the limestones are apparently wanting; mica-slates, black and grey, with bands of hard quartzose grits, being the prevailing strata.* These are, like the preceding, pyritous, and dip north-westerly at angles of 40° to 90°. They are also often highly metamorphic, but in most cases this feature is plainly due to local intrusions of granite. Throughout the greater part of this extensive area no fossils have yet been found.

No attempt was made in 1847 to separate the fossiliferous beds of Dudswell and other places from the non-fossiliferous slates and black graphitic limestones of the section just described, though a very considerable difference in the lithological aspect of the rocks of the two series is manifest. The descriptions of the various members as given

Rocks of the eastern area formerly regarded as belonging to one series.

* See page 433, Geology of Canada, 1863.

in 1847-48 were repeated in 1863 (see Geology of Canada, Chap. XVI, Gaspé Series); and, in addition to the large area already noted, a second and somewhat extensive basin-shaped tract was described as presumably forming part of the same series. This was stated to occupy the country extending north-east from Lake Memphremagog, on both sides of which, slates and limestones, both of the fossiliferous and non-fossiliferous series, are developed, to the vicinity of Ham Mountain; bounded on the west by the serpentinous belt of Shipton, Melbourne and Brompton, and on the east by the range of hills known as the Stoke Mountains, the extension of which to the south-west reaches Lake Memphremagog between Georgeville and Fitch Bay, near Magoon's Point. The sediments in this area differ somewhat from those already described. The calcareous beds are to a large extent absent, while there is a greater development of the greyish and black plumbaginous slates. Their Silurian age was inferred by Sir Wm. Logan from the presence of limited areas of slates and limestones, holding fossils, such as corals and crinoids, like those of Dudswell, and which were at that time supposed to constitute an integral portion of the rocks of this area, the upper beds being regarded as Devonian and the lower beds as Silurian and referable to the Gaspé series. Central or St Francis area

The rocks of the eastern area are now regarded as the extension northward into Canada of those described by Prof. Hitchcock, under the heads of "Calciferous mica-schist" and "Coos group," (see his Report on Geology of New Hampshire, 1877.) In the map accompanying that report the distribution of these groups into Quebec is given for a distance of about twenty miles north of the boundary. Following the geological map of Canada, 1866, the calcareous portion, embracing the limestones and slates of the first three miles of the section east of Massawippi Lake and Fitch Bay, are colored as belonging to the Helderberg formation (Devonian), and supposed to be the equivalents of the fossiliferous limestones of Georgeville and Sargent's Bay. The aspect of these beds and their relations to the associated rocks will be presently considered. Report of Prof. Hitchcock, 1877.

While, therefore, the lithological character and non-fossiliferous condition of much of these sediments afford but little evidence by which their Silurian age can be determined, yet several areas belonging to this horizon are clearly recognized; and these for the portion of the province included in the accompanying quarter-sheet map, may be thus briefly described. Two distinct series recognised.

The most northerly exposure, omitting that which has already been referred to as occurring on the Chaudière, is found on Lots 20-23, R. III., Lambton, at the narrows of Lake St. Francis, and about four miles from the head of the lake. This outcrop of fossiliferous rocks is Areas of true Silurian rocks, Lake St. Francis.

first referred to in the Geol. Survey Rep. for 1849-50, p. 51, and later in the Geology of Canada, 1863, page 429, under the head of Upper Silurian. The rocks are brownish and greyish dolomitic slates and limestones, which in places contain an abundance of corals, for the most part apparently of Silurian genera. The band is very narrow; it occupies a limited margin along the east side of the first point, and terminates at seventy-five yards from its extremity, where the fossiliferous beds rest against highly metamorphic talco-felspathic and quartzitic schist, which in some places passes into a conglomerate, and belongs to a much lower horizon. A second exposure, also of very limited extent, occurs at the extremity of the adjacent point to the west, separated from the former by a very narrow inlet. These fossiliferous rocks are apparently in closely infolded lenticular basins. Shorewards, they are seen in a small knoll to the right of the road leading down the north side of the lake from Lambton village. Their unconformity to the underlying schists and gritty beds is here quite clear; the newer beds dipping N. 80° E. $<$ 25°, and the older N. $<$ 60°. This outcrop of the Silurian is not more than fifty yards wide. Easterly, its limit cannot be ascertained, owing to the dense forest growth, but the beds do not apparently extend to any great distance, seeming rather to occupy the crest of a low ridge which extends from the narrows of the lake in this direction. On the south-western or opposite side of the lake, the fossiliferous rocks do not appear at all, though the slates and conglomerates are well developed a short distance to the west.

Mode of occurrence.

Limestones of Stratford and Lake Aylmer.

Proceeding south-westerly, the next exposures of limestone are seen in the vicinity of Stratford P. O. and on the shores of the points at the entrance of Ward's Bay, on Lake Aylmer. In these outcrops no fossils have yet been observed. The Stratford beds and all those to the east of the lake are evidently distinct from those just described, being probably the extension of the limestones seen in the first part of the section between Massawippi Lake and Canaan. They are arenaceous and graphitic, and of black and dark grey colors, and presumably belong to the older series presently to be described. Other outcrops of limestones, nearer the east shore of Lake Aylmer, are highly dolomitic and crystalline, and are apparently a part of the hard felspathic, chloritic and micaceous schist series which forms a prominent ridge in this direction.

Silurian of Ward's Bay.

The beds on Lake Aylmer at the entrance to Ward's Bay, though showing no fossils, resemble much more closely the recognized Silurian limestones of other localities. Their unconformity to the underlying slates, grits and conglomerates is also very manifest, and they have at this point the structure of a shallow synclinal, which is probably

the northern extremity of the St. Francis River basin; since similar rocks can thence be traced continuously to the vicinity of Dudswell. At various places these are highly fossiliferous. Thus, about one mile to the north of Weedon village, large corals and crinoids, probably of Silurian age, are found in the limestones, which form an apparently continuous belt extending along the road to Lake Aylmer, where they unconformably overlie hard, cherty, felspathic and somewhat gneissic rocks, fragments of which are found in the beds near the contact. Between Weedon and Marbleton, the rocks of this series are seen at intervals, in a depression which is bounded on the west by a high ridge of grits and conglomerates, which extends from Marbleton to Garthby and which evidently belongs to an older series. Near Marbleton, the Silurian limestones are in places comparatively unaltered, in others highly metamorphic. This alteration is more apparent at Lime Ridge, where the extensive works of the Dudswell Lime and Marble Company are situated, and where ridges of highly crystalline limestone occur, in which the quarries of this company are opened. Their Silurian age is, however, evidenced by the presence of crinoids and corals, even in the most altered portions. On Lot 22, R. VII., Dudswell, outcrops of crystalline limestone are also found, of excellent quality and in great variety of color. Some of the beds are of the kind known locally as "black and gold," and referred to by Sir W. E. Logan, Geology of Canada, 1863, pp. 432 and 827, where their resemblance to the celebrated Portor marble of Italy is pointed out. Attention was directed to the possible economic value of this deposit as early as 1847, and during the past year a company has been formed in Sherbrooke for the purpose of thoroughly testing its value. A channelling machine has been set to work, and an area of about forty feet square stripped, to get rid of the somewhat shattered surface stone. The marble becomes much more compact in the second bench, and presents a great variety of colors and markings, some of which are exceedingly beautiful. Some of the ledges are composed almost entirely of corals, often of large size, the internal structure of which, when brought out by polishing, presenting a handsome and striking appearance.

Fossiliferous limestones of Weedon.

Marbleton and Lime Ridge.

Dudswell marble quarry

The crystalline character of the limestone continues at intervals to within half-a-mile of Dudswell Corner, although comparatively unaltered limestone and shale also show here and there along the road from Lime Ridge and in the fields adjoining. In places the rocks have a very rusty, dolomitic look, weathering to an intense brown. They rest upon slates and gritty schists of the older series which flank the range of the Stoke Mountains. A short distance south of Dudswell, the attitude of the beds appears to indicate the extremity of the syn-

Dudswell centre.

clinal basin in this direction. The valley of the St. Francis River, between this place and Sherbrooke, is largely occupied by sand and gravel, and the exposures are very few, while those seen appear to belong to the lower graphitic limestone series, presently to be described.

Flagstone quarries at Dudswell.

On the eastern side of the lake at Dudswell, the rocks are more flaggy, and a number of flagstone quarries have been opened within the past four years. The stone is admirably suited for that purpose, and a market is easily obtained in Montreal.

Limits of the Silurian basin.

The eastern limit of the Silurian basin at this place is difficult to determine, owing to the great covering of drift, but it appears to be not far from the beginning of the ridge near the line between the townships of Dudswell and Bury, where black ferruginous slates and hard arenaceous limestones of the lower series come in. The southern limit of the basin is also to some extent conjectural.

North Hatley.

In the vicinity of North Hatley, at the outlet of Massawippi Lake, fossiliferous shales, similar to those already described, are seen, resting unconformably upon the black, graphitic limestones. The fossils apparently indicate a Lower Helderberg horizon. The outcrop is very limited, but the rocks resemble those seen near Georgeville and Knowlton's Landing, on Lake Memphremagog. The areas of Silurian around this lake, though not within the quarter-sheet map now referred to, may nevertheless be briefly noted, as they are connected with other areas within the map further to the north-east. The largest of these occupies both sides of the lake, from the outlet at Magog village to a distance on the east side of nearly three miles above Georgeville. On the west it terminates at Gibraltar Point, on the north side of the entrance to Sargent's Bay. A smaller, but disconnected, wedge-shaped area extends south from Knowlton's Landing, on the west side of the bay, for several miles, the contact between the Silurian rocks and the underlying black limestones and shales being marked by a fault. Traces of plant stems are found in some of the sandy layers of this area, which resemble very closely those seen in the beds of Lower Helderberg age at Dalhousie, on the Bay of Chaleurs.

Memphremagog Lake.

Limit of Silurian at Magog.

The Silurian rocks do not extend far inland on either side of Lake Memphremagog, but form a narrow margin resting on black slates and sandstones, the former of which contain graptolites of Cambro-Silurian age, and are of an entirely different character. At the foot of the lake, the Silurian basin evidently terminates in the flat ground along the lower part of the Cherry River about two miles from the shore, the contact with the Cambro-Silurian strata being visible on the road to Lake Fraser, on Lot 2, R. XVI., Magog. On the west side of the lake, the contact is seen on the road at the brook crossing on Lot 5, R. XV., Magog.

The only other areas of Silurian rocks noted in this section are found in the township of Stoke, except a very small outlier in the western part of Dudswell. In the former locality, sandy and calcareous slates, with thin and impure limestone bands, brownish-grey in color, form a narrow basin, infolded with the older rocks, and extend from the middle of L. 14, R. V., Stoke, to L. 10, R. X., Dudswell. At Stoke Centre, these fossiliferous strata rest upon hard schistose conglomerate and bluish-grey slate on the west, and on the east are bounded by hard, white-weathering felspathic quartzites, which are associated with black, irony slates, presumably of Cambrian age. These Silurian rocks are well defined, not only by their characteristic fossils, but by their lithological resemblance to recognized Silurian strata seen at other points. The Stoke area is apparently separated into two portions, the more northerly of which, extends from Lot 12, R. X., along the road through North Stoke into Ste. Camille, and is largely composed of conglomerates, associated with dolomitic brownish slates, the former made up of pebbles of hard grit and slate in a slaty and gritty paste. In places this conglomerate is difficult to distinguish from others which belong to a much older horizon, except for the evidence of the contained fossils. These are mostly corals and crinoid stems, which resemble those found near Georgeville. On Lot 11, R. XII., Stoke, half-a-mile to the west of the main road, there is a considerable outcrop of crystalline limestone, similar to that of Lime Ridge. This basin apparently terminates not far from the forks of the road from North Stoke to Marbleton. Its eastern limit is probably near the depression marked by the brook which flows from this road to Stoke Centre, the coral-bearing conglomerate and shales occupying the slope of the hill to the west, while the first rocks seen to the east are the hard, irony slates which flank the Stoke Mountain range.

Silurian areas of Stoke.

Further north, on a new road between Lime Ridge and Ste. Camille, a small outcrop is seen on Lots 14 and 15, R. IX., Dudswell, resting unconformably upon hard quartz grits and black slates.

The very marked contrast which exists between the fossiliferous Silurian rocks just described, and the slates and sandstones, many of which are highly quartzose, together with the dark-grey and often graphitic limestones, so abundant in the great area to the south-west, will be apparent to anyone who carefully studies the characters of the several series. Confirmatory evidence that the greater part of the rocks formerly regarded as Upper Silurian really belong to older systems, is furnished by the presence, at several points, of serpentines, conglomerates and hard quartz-schists, similar to those recognized as constituting an integral portion of the volcanic

Contrast between the Silurian and associated rocks.

Graptolites.

belt of the Eastern Townships. The recent discovery also of graptolites and other fossils of Cambro-Silurian age in these so-called Silurian sediments, bears still more strongly in this direction, and lends confirmation to the correctness of the somewhat extensive changes made in the accompanying map, as compared with that of 1866.

Complicated structure.

The present distribution and mode of occurrence of the various patches of Silurian rocks, make it highly probable that strata of this age once covered a very considerable area; and that, in the subsequent periods of disturbance and folding, these became so intricately involved with the underlying older rocks, which apparently ranged from the Pre-Cambrian to the Cambro-Silurian, as to make these remnants appear, at first sight, to be integral parts of the older systems.

D. Cambro-Silurian.

Three principal areas.

To this system must now be referred certain areas of graphitic, blackish or dark-grey limestone, with, in several localities, associated slates and sandstones, already in part described; and for convenience of reference, these may be divided into eastern and western areas. To the latter belong the calcareous rocks of Richmond, Danville, Warwick and Arthabaska. To the former, those of Stanstead, Hatley, Compton and Eaton, with their extension north-east to Stratford and Lake St. Francis, formerly considered as of Silurian, or in part Lower Devonian, age, but now known to contain fossils similar to those found in the limestones of the western areas, and which have been since 1874 recognized as of Cambro-Silurian, probably Trenton Utica, age. To this system also must be assigned a considerable thickness of black, blue and grey, often plumbaginous slates, with sandstones, which occupy the greater part of the large area north of Memphremagog Lake, also described in former reports as of Silurian age, but whose unconformable relations to the recognized fossiliferous Silurian just described, together with the presence of fossils, graptolites, etc., similar to those found in the St. Lawrence area, renders the present change necessary.

Kinds of rocks in the eastern areas.

The characters of many of the rocks of the eastern areas have already been described in the preceding chapter. Associated with the limestones, however, are certain blackish and bluish slates, which from their peculiar aspect are easily recognizable over a great extent of country. These are frequently thickly dotted with ochreous spots, probably resulting from the decomposition of a ferruginous dolomite or bitter spar. On fresh surfaces these spots have a pearly lustre and a brownish-grey color. Many of the sandstones also are similarly dotted, but the spots are generally smaller. The rocks have frequently

a brownish tinge, and are charged with cubes of iron pyrites, generally of small size, but at times reaching dimensions of nearly an inch. Near the contact with the granites, these strata are considerably altered, crystals of chiastolite and mica being produced, and a somewhat gneissic or schistose structure imparted for a short distance from the granitic mass. In places the graphitic slates are minutely wrinkled, and quartz veins, oftentimes of considerable size, are observed at various points.

The sediments which are found throughout the greater part of the area north of Lake Memphremagog, and on either side of that sheet of water for several miles, differ somewhat from those of the eastern section. They consist mostly of different colored slaty rocks, often in large slabs which in places have been quarried for flagging stones, more particularly on the west side of the St. Francis River, in rear of Brompton Falls. The limestones are apparently confined to very limited areas, and in character are like those of Richmond and Hatley. As in the eastern area, the slates are frequently ochre spotted. They are also occasionally well defined by a regular alternation of color bands, black, grey or bluish, giving them a characteristic striped appearance, which on freshly uncovered surfaces is very distinct. This feature of the slates is exceedingly persistent, certain bands being easily traced almost without a break from near the Vermont boundary northward beyond the Chaudière River, at which place they are well displayed on the road down the west side of the Gilbert stream. These slates are for the most part highly cleaved, and their bedding is very obscure, except where a good cross section is afforded by a cliff or cutting. In the vicinity of South Ham village, and in the northern part of the township of Ste. Camille, hard, cherty, felspathic-looking slates occur, which break with a conchoidal fracture, and very closely resemble strata seen at various points along the south side of the River St. Lawrence, as at Griffin Cove, Marsouin, etc., where they are associated with, and apparently form an integral part of, what has been regarded as the Hudson River or Utica formation. (See Geol. Sur. Rep., 1880-81-82, p. 18 DD.)

The Central or St. Francis River area.

Hard cherty slates of South Ham.

The rocks of the western area have already been very fully described in earlier reports, and their lower or Cambro-Silurian age established. They presumably occupy much of the flat country lying to the west of the ridges of altered slates and other metamorphic rocks seen at Arthabaskaville and which extend thence south-westerly towards the St. Francis River. They also occur in unconformable patches or narrow strips upon the older schists, and occupy depressions between the Cambrian and Pre-Cambrian hills. Sections of the limestones from different and widely separated points show them to be largely

The western area.

Unconformity to underlying schists.

Age determined by means of the microscope.

composed of organic remains, the microscopic examination of which proves them to belong to the Trenton group, their horizon being apparently about that of the upper portion of the Chazy formation.

Graptolites of Lake Memphremagog first noted by Sir W. E. Logan, 1847.

In 1847, Sir W. E. Logan found graptolites in loose pieces of slate on Lot 5, R. XIV., Bolton, now the township of Magog. It was stated that these were evidently not far removed from the place whence they were derived. (See Geol. Sur. Rep., 1863-66, p. 31.) During last season, 1886, an examination was made of this locality with the hope of finding these fossils *in situ*. This expectation was realized by the discovery of highly graptolitic slates in at least two places, the first on Lot 7, R. XV., Magog, about 150 yards south of the forks of the road along the west side of the lake; the second on the eastern side of the lake, on Lot 19, R. II., Stanstead, in a cutting on the main road, about 100 yards north of the entrance to the grounds and residence of the late Sir Hugh Allan. The fossils of both places appear to belong to the same horizon, and may be from portions of the same beds which appear on either side of a sharp synclinal that underlies the basin of the lake. They have been submitted to Prof. Lapworth, who has made a special study of graptolites, and he has kindly reported on these as follows:—

Lot. 7, R. XV., Magog.

Prof. Lapworth's remarks.

"Matrix, soft, thin-bedded and flaking silvery shales, greenish-gray in color (originally black), apparently altered and spotted by contact metamorphism.

1. *Dicranograptus ramosus*, Hall.
2. *Diplograptus angustifolius*, Hall.
3. *Diplograptus foliaceus*, Murchison (=*pristis*, Hall.)
4. *Diplograptus perexcavatus*, Lapworth.
5. *Climacograptus bicornis*, Hall.
6. *Climacograptus cœlatus*, Lapworth.

The fossils are all in a most miserable state of preservation, but all the forms named above are easily recognizable. These fix the age of the strata as Utica or Marsouin or Norman Kill, but somewhat higher in the series than the typical Norman Kill beds. They may safely be termed Upper Llandeilo or Lower Bala, and placed generally above or about the horizon of the Trenton or Utica rocks of the western area.

Lot 19, R. II., Stanstead.

1. *Diplograptus foliaceus*, Murchison.
2. *Dicellograptus sp.*, allied to *D. Forchammeri*, Geinitz.

3. *Dicellograptus divaricatus*, Hall.
4. *Climacograptus perexcavatus*, Lapworth.
5. *Corynoides calycularis*, Nicholson.
6. *Dicranograptus sp. ?*

The state of preservation of these fossils is so poor that it is impossible to identify any of them with absolute certainty. They are all clearly of the same general facies as those of Magog, but better specimens should be obtained before the matter can be satisfactorily determined."

The beds from which these graptolites were obtained are probably the same as those noted by Sir W. E. Logan in 1847, referred to above. They consist of greyish and blackish, often highly plumbaginous slates, with occasionally coarser sandy beds. A short distance south of the locality, on the west side of the lake, crinoid stems were found in ledges of similar slates along the road-side. Crinoid stems.

The slates just described have a very considerable development. They extend north-easterly through Brompton, Wotton, Ste. Camille and thence to the Chaudière. They have a breadth of ten to twelve miles in their widest part, which is in the township of St. George de Windsor. Throughout their whole extent they vary but little in character, and can generally be recognized without difficulty, even though fossils are not often seen. Distribution.

Returning to the western area, we find presented in the townships of Melbourne, Cleveland and Shipton one of the most puzzling problems connected with Eastern Townships geology, and concerning the true explanation of which much discussion has arisen. Complicated structure of the western area.

In the Geology of Canada, 1863, pp. 239-40, it is stated that "the lower black shales which are brought into view along the line of the Boyer and Stanbridge anticlinal, near Farnham, are intimately associated with thin black and dark grey limestones which contain fossils, the aspect of which is more recent than might be expected in the Potsdam formation." The difficulty of separating these two series seemed so great that Sir Wm. Logan says:—"Except, however, where such fossiliferous strata are known to occur, the black slates and limestones will be provisionally described as older than the Quebec group." These rocks, on being traced to the north-east, were found to extend continuously past the Kingsey ridge and to occupy the valley between Danville and Richmond, whence they could be traced at intervals south-westerly into Ely and Stukely. While there is every reason to believe that the calcareous rocks of the Danville and Richmond depression are of the same horizon as the fossiliferous limestones of Farnham, it has been quite conclusively established, as already pointed out, by microscopic examinations of Early views of Sir W. E. Logan.

2

Correct view of the structure first indicated by Dr. Selwyn.

the contained organic remains, that these do not belong to the Potsdam, but are much more recent in age, and are, in fact, a part of the Trenton group, brought into their present position as has been pointed out by Dr. Selwyn in the publications mentioned, p. 6 J, by an intricate system of folding and faults.

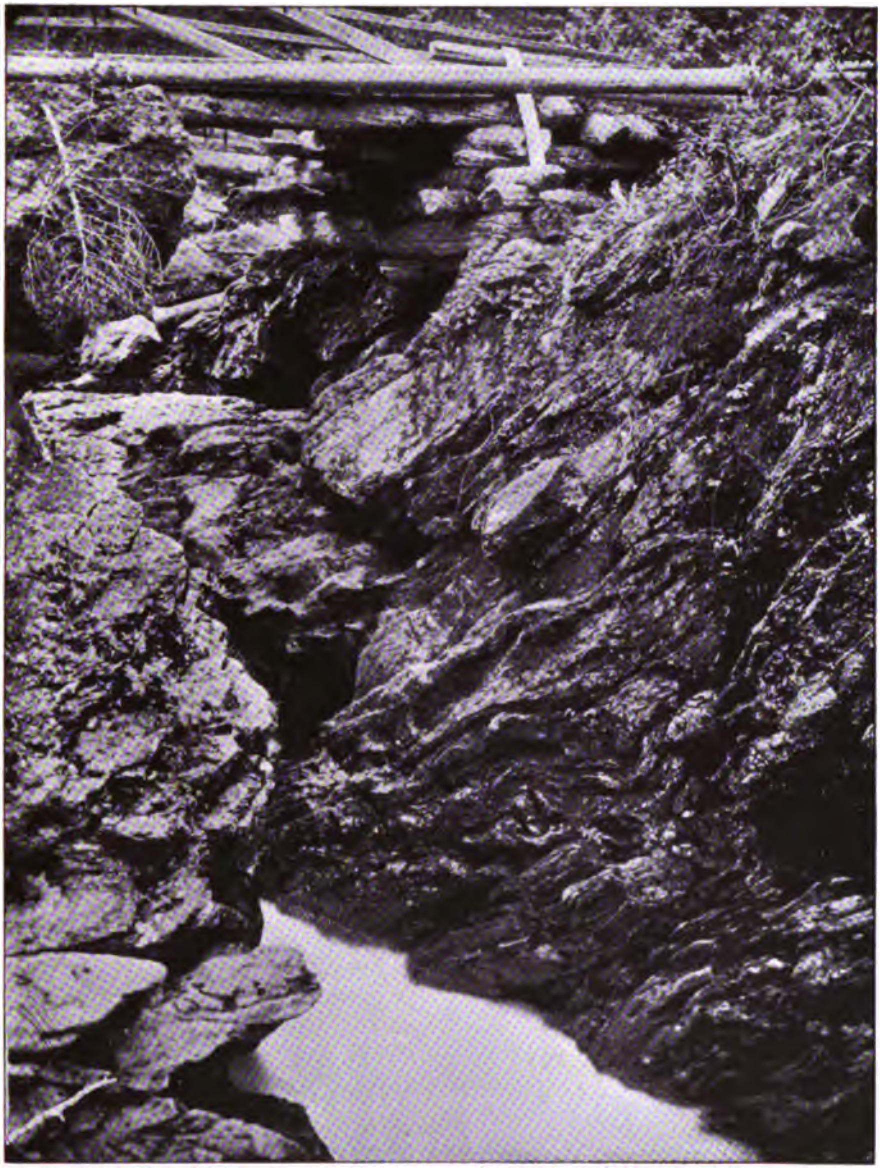
Structure at Danville and vicinity.

From Melbourne, north-east to a distance of several miles beyond Danville, the black limestones and calcareous slates form a very continuous but generally narrow band, confined for the most part to the depression along which the Grand Trunk Railway is constructed. At several points the structure seems to be that of a true anticlinal in the calcareous beds, making them appear to underlie the great series of hard metamorphic schists and slates, with serpentines and quartzites, which constitute the prominent ridges on either side, and between which, in places, there appears to be a real conformity. Hence, it was formerly supposed that there was a regular passage upward from the limestones at the base into the overlying schists and associated rocks. On careful examination at other points, this apparent conformity is, however, found not to exist, since, by tracing these rocks to the north, the relative position becomes reversed and the limestones are found to rest at many points unconformably upon the altered rocks. These relations are well seen at Arthabaskaville, at Warwick, and along the road thence toward Kingsey Falls. At other points also, as at Trout Brook P. O., in Tingwick, and at several places between Castlebar and St. Patrick's Hill, the limestones occur in patches, often of very limited extent, resting unconformably on the schists.

Gorge of the Nicolet River.

The section which is perhaps most difficult of interpretation is that found in the Nicolet River at the gorge, about a mile east of the Danville road. At this point a well defined anticlinal is apparent in the black limestones, and on the south-east side these appear to dip regularly beneath highly metamorphic schists and hard quartzose rocks. The succession to the west is wanting at this point, the surface being largely covered with drift. There is nothing at this locality to disprove the apparent structure, except the more highly altered character of the overlying series as compared with the fossiliferous character of the limestones beneath. To the north, however, on a road leading east from the main road which extends from Castlebar to St. Patrick's Hill, a true anticlinal structure is seen, the lowest beds being hard metamorphic slates and schist, upon which the limestones are placed unconformably, an order of things which is noted at several other points in this direction. A somewhat similar structure to that found at the gorge of the Nicolet is exhibited along the line of the Grand Trunk south of Danville for some miles, where the calcareous beds are observed to dip apparently beneath the older

Grand Trunk south of Danville.



T. G. WESTON PHOTO., 1879. IVES-PROCESS; G. E. DESBARATS & SON, MONTREAL.

GORGE OF THE NICOLET RIVER, SHIPTON, QUEBEC;

SHOWINGTHE JUNCTION OF PRE-CAMBRIAN SCHISTS WITH CAMBRO-SILURIAN CARBONACEOUS LIMESTONES.

T. C. WESTON, PHOTO., 1879. IVES-PROCESS; G. E. DESBARATS & SON, MONTREAL.

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looking rocks on either side. Careful examinations of these localities, however, disclose the presence of profound faults throughout this whole region. The limestone strata near the contact with the overlying beds are frequently crushed and distorted, while there is often a wide diversity in the dips of the two series. In this way at the gorge also, where apparently a heavy transverse fault, just to the north of Danville Village, complicates matters considerably, we must refer the apparent superposition of the schists upon the limestone to the occurrence of a sliding fault, probably of considerable extent, by which the older measures have been thrust upward into their present position.

Heavy faults.

South of Danville, towards Richmond, the position of this fault can be ascertained with considerable accuracy. It evidently crosses the St. Francis River, and extends towards the Vermont boundary, along the line of the Missisquoi River and Valley, as a similar displaced condition of the various rock formations is visible in this direction. This, however, is an area which requires to be yet worked out in detail.

Potton and Danville fault.

To the north of Danville, the fault evidently continues in the direction of the depression leading towards Warwick station. The surface is, however, so deeply covered with sand, and rock exposures are so rare, that it has not been attempted to define its position with any pretence to accuracy. The limestones and calcareous slates of the newer series doubtless continue to occupy the valley in this direction. They are well exposed in the stream at Gilman's mills, west of Danville, and at several points further to the west, as indicated on the map. To the north their contact with the overlying schists which form a prominent ridge extending from the vicinity of Kingsey Falls to the crossing of the Ruisseau des Pins, at Warwick, is seen on Lots 24 and 25, R. V., Tingwick.

Danville and Warwick.

At Arthabaskaville, the contact, or superposition of the limestones of the newer series upon the older schists, is seen at a mill on the east branch of the Nicolet River, whence the former extend north-westerly to Arthabaska station, where they are again well exposed in the stream, dipping south-easterly, and showing the presence of a synclinal between these places. To the south-west of the former locality, the outline of the Cambro-Silurian keeps near the main road leading through St. Madore to Warwick, the characteristic fossiliferous limestones being seen about three-eighths of a mile north-west of Warwick station, as well as at several points along that road. The connection of the Danville area with the great area of the flat country west of Arthabaskaville has not yet been traced, owing to the covering of sand, but to the south-west the fossiliferous limestones show at several points

Arthabaskaville.

Drift-covered country.

on the road along the west side of the ridge leading to Kingsey, as far as Lot 23, R. I., Warwick, whence their contact with the underlying series is again seen.

Kingsey Falls and French Village.

The contact of the limestones is further noted a short distance to the west of Kingsey Falls, whence, with a curving outline, it extends in the direction of French Village.

Present views of the structure considered.

That the views concerning the structure and relations of the two series of rocks above described are probably correct, is evidenced by a glance at the stratigraphical position of the Quebec group, as given in the Geology of Canada, 1863, where it is stated to be intermediate between, and to comprise portions of, the Calciferous and Chazy. The horizon of the fossiliferous black limestones being conclusively established as not lower than Chazy, it is manifest that their assumed position beneath rocks which have formerly been regarded as the equivalent of the Levis and Sillery formations, but which are probably, in some cases at least, much older, cannot be sustained; and that the peculiar stratigraphical relations now seen at certain points can only be explained, as above described, by a series of faults and intricate infolding of newer with older rocks, a feature already pointed out in the proceding chapter as also affecting the position of certain Silurian areas. To the south-west of Richmond, the fossiliferous limestones which have been recognized in the direction of Stukely are brought into intricate association with highly metamorphic strata through similar agencies. At South Ely, fossils have been found in these rocks which resemble those of Danville and Arthabaskaville, but the precise outlines of these newer areas have not yet been traced.

Fossils of South Ely.

The areas of fossiliferous limestones and associated graphitic and calcareous slates just described are for the most part situated on the west flank of a broad belt of rocks of various characters, portions of which are highly metamorphic, resembling very closely Pre-Cambrian rocks of other localities; while other portions, much less altered, have more the aspect of Cambrian sediments. The consideration of these groups will be presently taken up.

Limestones of the St. Francis area near Windsor.

At several points, resting upon the latter, more particularly in the central area, similar limestones occur. These are seen on the north side of the St. Francis River, on Lot 5, R. XII., Windsor, as well as on the south side of that stream. A considerable area is also found on the upper part of Sargent's Bay, and in the vicinity of East Bolton and Peasely's Corners, and, extending south of that bay, between the Sugar-loaf Mountain and the road up the west side of Lake Memphremagog.

West side of Lake Memphremagog.

The limestones of the area lying to the east of the Massawippi and Stoke Mountain range, formerly regarded as Silurian, but

now proved, from the evidence of the contained fossils, to be Cambro-Silurian, have already been described. In the sections of rock from Hatley, the microscope revealed the presence of crinoids, and other fossils, like those of the Melbourne and Danville area. Their unconformity to the overlying Silurian fossiliferous beds was first pointed out by Sir Wm. E. Logan. (See Geological Survey Report for 1847–48, p. 48.)

Fossils in the black limestones of the Eastern area at North Hatley.

East of the line which bounds the calcareous portion of this formation in the eastern area, the limestones are rarely seen. With the exception of the limited outcrop in Barford, already noted, none were observed till we reach the village of West Stewartstown, on the Upper Connecticut River, in the adjoining state of New Hampshire, where the siliceous limestones, presumably of this formation, have been observed by Prof. Hitchcock. (See Geology of New Hampshire, 1877, p. 41.) On the line of the International railway, about three miles west of Marston station, a small cut is made in limestone of this character, and is the only indication of these rocks in this direction east of Robinson station.

Limestones of West Stewartstown, N. H., noted by Prof. Hitchcock.

The calcareous beds, while not continuous to any great extent in either direction, apparently occupy crumpled or possibly overturned synclinal basins in the ochre-spotted slates and sandstones, which might in this case indicate the denuded crests of small anticlinals, of which doubtless a number exist in the thirty miles between the metamorphic ridge and the New Hampshire boundary. In no other way can we account for the enormous thickness which would otherwise result from such a continuous and regular series of north-westerly dips as are found in this area.

Probable structure of the Eastern area.

The extension of these beds can be traced north-easterly to the Chaudière River, and thence in an apparently unbroken area along the boundary between Quebec and Northern Maine. The distribution of the several groups has not yet been worked out in this direction, but limestones similar to those just described are found on the north-east branch of the St. John River, indicating the presence of rocks of Cambro-Silurian age in that vicinity.

Extension northward.

On the Chaudière, between the outlet of Lake Megantic and the junction of the Famine River, about three miles below the forks of the Du Loup, a distance in all of some forty-three miles, the rocks are for the most part argillaceous and micaceous slates, in places blackish and graphitic, with grey sandstones, some of which are hard and resemble quartzite, while others are schistose. Beds of sandy limestones, in many cases too impure for burning, are seen at intervals, and the rocks are often intersected with veins of quartz, some of which may be auriferous. The character of the sediments in this area is similar to that

Distribution on the upper Chaudière.

of those in the line of section between Massawippi and the New Hampshire boundary.

Association with older rocks on the Chaudière below the Famine River.

On the Chaudière, a belt of hard green quartz-schist, seamed with quartz veins, comes in on the west side of the Famine River. These are associated with beds of hard, twisted altered slates, which in places are plumbaginous, and resemble in many respects the slates of the Ditton gold field. They are underlain half a mile lower down by hard felspathic schists, containing talcose matter, which in places pass into gritty or schistose conglomerates. These doubtless belong to an older series. Thence to the Gilbert River hard irony slates and quartziferous schists, sometimes highly felsitic, occur. On the west side of the latter stream the banded slates of the Wotton area are again seen, and are here apparently the continuation of the middle or St. Francis River division of the Cambro-Silurian, described in former pages, and which can be traced through Garthby and Price to this point. Further detailed examination is, however, necessary to work out the exact structure of the several groups of widely differing rocks in this section.

Rocks for the most part barren of fossils.

Except in bands of black and grey graptolitic slates on either side of Lake Memphremagog and in the areas of dark fossiliferous limestone of Hatley and other places, no fossils have been found throughout any part of this Cambro-Silurian area, presenting in this respect a marked contrast to the areas of Silurian rocks. At one point on the International railway, between Spring Hill and Marston stations, certain markings which somewhat resemble fucoids, but the nature of which is uncertain, were found in the sandy slates.

Stratigraphical relations to the older rocks.

The Cambro-Silurian age, assigned to these rocks in the present report, is based chiefly on the fact that they are intermediate between the black fossiliferous limestones already mentioned, and a series of black wrinkled slates and schistose, though often massive, sandstones, which constitute the rocks of the gold fields of Ditton, Emberton, and the country about the head waters of the Du Loup, and which in character precisely resemble those of the gold fields of Nova Scotia, long regarded as of Cambrian age.

It is possible, however, that a portion more immediately overlying the older, or what must be now regarded as the Lower Cambrian, may belong to the upper part of that system, but at present we have no palæontological evidence to warrant such a separation, and they are therefore described as a portion of the Cambro-Silurian system.

Granitic intrusions.

Throughout the area in question, intrusions of granite are frequent. At times these occupy large areas, at others they form bosses of limited extent, or even occur as dykes. Their action upon the strata in contact with them is everywhere the same, producing a high degree of metamorphism, well indicated by the presence of crystals of mica,

chiastolite and staurolite, and at times by the development of a gneissic structure in the sandstones, while the slates frequently assume a schistose appearance, differing but little from that observed in the older crystalline rocks. Similar metamorphism is at times noted at points far removed from any visible granitic exposure. In such cases it is probable that the granite is at no great distance below the surface. This feature is observed at the marble quarries in Dudswell, where the metamorphism, is evidently local, and presumably proceeds from the presence of underlying masses of granite rock. In places, where these granite masses now form hills, with an elevation of 800 to 1,000 feet above the surface of the surrounding country, the denudation of the slates and sandstones around their base must have been enormous.*

Development of chiastolite and other minerals.

C. CAMBRIAN.

Underlying the great series of slates, sandstones and limestones just described is a second series in many respects resembling these, but with no calcareous beds in so far as has been ascertained, nor any fossils which would definitely fix their precise age. In position they are intermediate between what are now held to be Cambro-Silurian sediments, and the crystalline schists presently to be considered, and which are now admitted to represent, in part at least, the upper portion of the Archean or Huronian system.

Stratigraphical position of the Cambrian rocks.

These rocks present a considerable variety of characters, embracing slates of various colors, purple, black, green and grey, along with sandstones—often so highly quartzose, as to form in places a hard quartzite—quartziferous schists and conglomerates. The sandy and quartzose beds are very similar to some of the so-called Sillery sandstones of the Quebec group, and the few indistinct fossils that have been found in similar slates elsewhere are considered by Prof. Lapworth to be of Cambrian age, while other parts of the series may perhaps represent some of the lowest members of the same system.

Characters of the various rocks.

The conglomerates are of two kinds, the one largely composed of pebbles of granitoid rock, quartzite, slates, and hard felspathic schist, in a slaty or sandy paste, the other, which may perhaps more properly be regarded as an *agglomerate*, is largely made up of dioritic pebbles in a dioritic paste, with some intercalated beds of sandstone and hard grits. Portions of the slate series are schistose, finely wrinkled and often pyritous. The paste of the conglomerates is at times also schistose, and frequently has talcose matter disseminated in it.

Conglomerates and agglomerates.

* I do not concur in the explanation which regards the granite as the cause of the metamorphism. It is itself, I believe, as much a part of the effect of the metamorphosing agencies as is the present condition of the other rocks referred to.—ALFRED R. C. SELWYN.

Unconformity. These rocks are apparently unconformable, and in places clearly so, to the bluish and banded slates and limestones of the Cambro-Silurian system on the one hand, while they are in like manner uncomformable to the underlying ridges of crystalline rocks, from the debris of which they are largely formed.

Limestone conglomerates. As compared with the rocks of the St. Lawrence area, these are on the eastern side of the central axis, distinguished by an almost entire absence of limestone conglomerates which form so conspicuous a feature in the former. Such conglomerates are, however, found in at least two places, the first on lots 5 and 6, Range IX., Chester, the second on lot 25, Range V., Weedon. The slates, more especially in the lower portion, are often schistose, and have a minutely wrinkled and ligneous aspect. The sandstones also are frequently schistose, and in places have almost a gneissic structure, as if subjected to great lateral pressure, or shearing, and, as a whole, are more quartzose than those of the Cambro-Silurian system. In places, quartz is very abundant in the form of veins, which range in size from mere threads to a thickness of several feet, and occasionally interlace in all directions.

The rocks which are now regarded as Cambrian for the most part flank the ridges of crystalline schists and gneissic rocks. They are well seen in connection with these on the extension of the Sutton Mountain anticlinal to the north-east, where they are largely developed in the townships of Shipton, Tingwick, Chester and Wolfestown. The Cambrian strata at times appear to lie in intricately infolded basins, at others they are seen to lap around the ends of the ridges of older rocks. They are divided into two great areas by the Stoke and Massawippi Mountain range, the more westerly underlying the Cambro-Silurian rocks of the St. Francis River areas, while that to the east presumably underlies the stretch of country between this range and the New Hampshire and Maine boundary. The rocks in both areas are to a large extent affected by crumpling, but this is perhaps less apparent in the eastern area, where, after passing the calcareous beds mentioned in the last chapter, there appears to be a somewhat gradual passage to lower strata as we reach the eastern limit, and in this direction it has been found difficult to draw any sharply defined line between the two systems.

Cambrian divided into principal areas by the Stoke Mountain range.

Cambrian recognized by Prof. Hitchcock. To the lower or Cambrian system, Prof. Hitchcock has referred a belt composed principally of blackish, wrinkled slates and schistose sandstones which form a ridge extending north-east from the vicinity of Canaan, between Hall's and Indian streams, to the Quebec boundary, (see map accompanying Geology of New Hampshire, 1877) and which presents a well-defined anticlinal structure. This anticlinal can be easily recognized in the adjoining townships of Emberton and Ditton,

whence it can be traced to the north-east, past the outlet of Lake Megantic to the road up the Du Loup, or main branch of the Chaudière, where it is seen on Lot 25, Kennebec Road Range, in the township of Linière. Throughout its whole extent, the rocks are alike, though perhaps there is a somewhat less percentage of the black slates to the north-east. Quartz veins, running for the most part with the bedding, though at times transverse to it, are found at many points. Some of these are undoubtedly auriferous, as evidenced by the quantity of loose and coarse gold found in the valley of the Little Ditton and on the several branches of the Chaudière, the gold at times being found, with ragged quartz attached, in close proximity to quartz veins. Their auriferous character is also clearly shown by the official assays of the quartz, from a number of leads (see Geol. Survey Report 1863-66, Hunt and Michel) and more fully referred to in the chapter on Economic Minerals. Argentiferous galena, is also found in considerable quantity and of a richness which promises profitable returns, if economically and properly worked, more especially in the townships of Risborough and Marlow. A fair percentage of gold, reaching half an ounce to the ton, has also been obtained from one of the veins of the Marlow Silver Mines by Prof. J. T. Donald, of Montreal; and according to Prof. E. Pagé, of Laval University, the silver in one of the veins ranged as high as 430 ounces to the ton, while in others yielded from 29 to 260 ounces.

Extension of the Eastern area.

Auriferous quartz veins.

Silver ore.

What is now regarded as probably the line separating the Cambrian rocks of Emberton and Ditton from the Cambro-Silurian of the eastern area, crosses the road from Ditton, through Auckland, about Lot 46, R. I., Emberton; those to the east being principally the black slates and gneissic or schistose sandstones of the goid series, while to the west are the banded and ochre-spotted slates and pyritous sandstones, associated with the limestones already described. At several points, however, in the great Cambro-Silurian area to the west, as on the roads between Sawyerville and Martinville, out-crops of hard, quartz-veined slates and sandstones occur, from which gold has been reported, and which may be the crests of Cambrian ridges exposed by denudation, but the separation of which from the Cambro-Silurian is not at present practicable.

Probable line of separation between the Cambrian and the Cambro-Silurian.

In character and aspect, the gold-bearing slates of Ditton and the area to the north-east, almost exactly resemble, as already intimated, the rocks of the Nova Scotia gold series. This is seen in the peculiar wrinkled appearance of the black slates, with similar quartz-veins, while much of the massive sandstone is almost precisely similar to the so-called whin of the eastern coast. Near the United States boundary, these rocks rest upon greenish chloritic and felspathic

Resemblance of the Cambrian of Ditton to the rocks of the Nova Scotia gold series.

Contact with Huronian of the Maine boundary.

schist, with diorites and gneisses, the former of which are sometimes massive, at others slaty, and hold quartz and epidote. Their contact with the Cambrian on the road which leads south through Emberton is seen about the line between ranges II. and III. Further south, on the height of land overlooking Lake Sophy, the rocks are hard felspathic schists of Huronian aspect. The line between the Cambrian and older series, while it cannot be followed closely, owing to wilderness and drift-covered country, is supposed to extend in a nearly straight course north-easterly to the upper end of Lake Megantic. On the International railway, it crosses about two miles west of the summit of the pass through which the railway enters the state of Maine, the last Huronian rocks seen in this direction being greyish-green talcose, smooth and wavy schists; succeeded, a little further west, by the greyish schistose sandstones and black and grey slates of the Cambrian series.

Chiastolite-schist.

Near the lower part of the exposed Cambrian slates, large ledges of purple-tinged chiastolite-schist occur, with hard, green and whitish-grey altered sandstone, interstratified with blackish-grey schistose slates and grits. The presence of the chiastolite crystals is probably due to the influence of a great mass of granite, indications of which, on the west side of the lake, are seen in veins of small size. The chiastolite schist has a breadth of half-a-mile northward from the granite mass. While these schists are also found in the Cambro-Silurian areas near the granitic rocks, their alteration does not appear so marked as in those just described, the areas being generally quite limited; but in the Cambrian, certain belts are found, as shown by the large blocks seen at various points, which are studded with large and coarse crystals of staurolite, exactly like the staurolite schist seen in the Nova Scotia series near the contact with the granites. These have not yet been found in any part of the Cambro-Silurian areas.

Staurolites.

Cambrian of the central or principal metamorphic belt.

The Cambrian rocks, associated with the central, or principal metamorphic belt, present characters somewhat different from those just described. Prominent among these are considerable areas of conglomerates, already briefly noted, which apparently form the lowest beds of this group, and are in part described in the Report for 1877-78, p. 3 A, where their horizon is stated to be presumably that of the lower portion of this system. The volcanic agglomerates are more particularly developed in the western portion of the area, while the true conglomerates, composed of *débris* of the old ridges in a slaty paste and with slaty bands throughout, are well seen in the eastern part. They are well displayed on lots 2 to 6, ranges III.-IV., Orford, in rear of the city of Sherbrooke, whence they can be traced in an almost continuous belt to Lake Aylmer. North of this they appear in force on the road

Conglomerates near Sherbrooke and northward.

from D'Israeli station, on the Quebec Central railroad, to the head of Lake St. Francis, on lots 21 to 30, ranges II. and III., Price. Associated with these, are heavy beds of siliceous grits, occasionally holding scattered pebbles and containing grains of clear quartz from the size of pin-heads up to nearly half an inch in diameter. What is probably the further continuation of this belt appears on the Chaudière between the Famine and Gilbert Rivers, the characters of which have already been described in the preceding chapter. Siliceous grits.

To the south-west of Sherbrooke, these conglomerates have a considerable development along the flank of Massawippi Mountain and on the road between the head of Massawippi Lake and Magog, where they rest upon greenish, chloritic schists, and are in turn unconformably overlapped by the banded and spotted slates of the Cambro-Silurian system. Massawippi Mountain.

Another group of rocks, well defined in character and easily recognized, at several points overlying unconformably the crystalline schists of the Sherbrooke ridge, and intermediate between these and the graphitic limestones, consists for the most part of dark-grey, often blackish schistose slates, somewhat glossy and in places thickly filled with cubes of iron pyrites. The surfaces are minutely wrinkled, and they closely resemble the wrinkled black slates of the Ditton gold fields, as well as portions of what have been regarded as Cambrian or possibly lower Cambro-Silurian slates in New Brunswick. These have an older and more altered aspect than the ordinary slates of the Cambro-Silurian area of the St. Francis basin. They are exposed in the vicinity of Lennoxville and on the road to the south-west in rear of that place; also along the Belvidere road south of Sherbrooke and on the east side of the Magog River and Little Magog Lake, where they contain quartz veins, which have been opened up in the search for gold. They extend from the south-west part of Massawippi Lake along the south side of the high metamorphic ridge, known as Bunker Hill, and thence along the north side of Fitch Bay to the shore of Memphremagog Lake at Magoon's Point. In this section, they appear to dip beneath the schists, as do also the graphitic limestones on the south side of Fitch Bay, a peculiarity of structure due, doubtless, to an overturned synclinal, as well as to a probable line of fault along the east side of the metamorphic ridge from this locality to Lennoxville and beyond. Cambrian slates of Lennoxville and vicinity. Their extension south-west.

In the counties of Wolfe and Richmond, other areas of rocks, presumably of this age, occur, intimately associated with the crystalline schists. Throughout this section, the prevailing dips of the several formations are to the north-west, and an apparent conformity exists between the crystalline portion and the slates and quartzose beds. This peculiarity, however, appears to be due in great measure to Cambrian of Wolfe and Richmond counties.

intimate infolding, whereby the comparatively unaltered slates are made to appear as integral parts of the older schist series. At some points, also, more especially near the extremity of the ridge, the slates are seen to overlap or sweep around in such a manner as to indicate an unconformity between the two sets of rocks. The slates of the upper portion are of various colours, purple, green, grey, and black, and no fossils have as yet been found at any point throughout their entire extent. They resemble the dark-red and olive colored slates, &c., along the St. Lawrence, which are now regarded as older than the Levis graptolitic zone, and underlie unconformably the black limestones of Warwick and Danville. The associated quartzose grits often contain blebs of clear quartz, resembling in this, as well as in other particulars, much of the rock seen in the vicinity of the quarries near Sillery Cove, above the city of Quebec, and they are presumably of the same age. The slates are also frequently cut by quartz veins like those of the Ditton gold field.

Intricate association with the older schists.

Resemblance to the Cambrian of the St. Lawrence.

Closely connected with the hard quartzites, schistose grits and slates just described, is a considerable development of volcanic rocks, which include diorite, dioritic agglomerate and breccia, dioritic schist, diabase and serpentine, etc. These form a well defined belt, extending from near the Vermont boundary west of Memphremagog Lake, with some interruptions for nearly or quite 150 miles. It crosses the river St. Francis a short distance east of Richmond, and the Chaudière in the vicinity of the Bras stream. This series is separated from the metamorphic and other rocks of the Sutton Mountain anticlinal by a fault, probably of considerable extent, clearly indicated in the depression between Richmond and Danville, whence it can be traced southwest down the valley of the Missisquoi River.* Indications of other faults of greater or less extent are also seen at various points, more particularly in the valley of the Nicolet, north of Danville, but the difficulty of tracing these in a country so largely covered with drift is such that their accurate delineation cannot now be attempted.

Volcanic rocks pertaining to this system.

Their extent.

Faults.

The rocks of this series are fully described in the Geological Survey Report, 1877-78, pp. 5 and 7 A. After crossing the St. Francis, the principal area extends with a uniform width almost to the northern boundary of the township of Shipton, when it suddenly bends to the eastward and terminates in the great mass of dioritic rock known as the Little Ham Mountain. The continuation of the same belt reappears in the prominent ridge known as Big Ham Mountain, a distance of about four miles intervening, which is occupied by slates of Cambrian aspect. From Big Ham Mountain the volcanic group

Their relations first pointed out by Dr. Selwyn.

Distribution northward.

* This is the Potton and Danville fault described by Dr. Selwyn in Vol. I., Trans. R. S. C., pp. 12-13.

continues almost without a break, and with a considerable breadth through the townships of Ham, Garthby, the eastern part of Wolfestown, and Coleraine, into Thetford, and includes the celebrated asbestus-bearing serpentine of this section. In all these areas the serpentines are closely associated with the diorites, of some portions of which they are undoubtedly, in part at least, an alteration product. Their relations can be well studied along the line of the Quebec Central railway north of Coleraine station and on the road between that place and Wolfestown, where in the vicinity of Belmina P. O. they are seen in direct contact with the black Cambrian slates on the one hand, and with hard whitish granulite on the other.* The latter, which sometimes assumes the nature of a granite, frequently occurs as huge masses or dykes cutting the serpentine rocks, both here and at Black Lake and Thetford. These rocks will be described more fully in a subsequent chapter.

Association of serpentines with dioritic rocks.

From the consideration of the facts here presented, the presence of three well defined Cambrian areas is recognized. Of the most easterly, or that near the New Hampshire and Maine boundary, the western limit is a tolerably direct line from the northern angle of the boundary in Emberton, to the line between Ranges VI. and VII. Metgermette, its eastern limit passing into the adjoining state about the line between Spalding and Risborough, in which direction it rests upon the Pre-Cambrian rocks which constitute the range of mountains forming the height of land along the International boundary.

Limits of the several Cambrian areas.

The second is exposed on either side of the Stoke Mountains and Sherbrooke anticlinal, whence it extends in a belt from four to six miles in width to the Chaudière, concealed in places by overlying beds of Silurian and Cambro-Silurian age, and separated from the eastern area by the great Cambro-Silurian crumpled synclinal of Compton and Beauce, while the third or western area also appears on both sides of the Sutton Mountain anticlinal, overlain in its central part by the great Cambro-Silurian basin of the St. Francis River area in the east, and by the black limestones of the Arthabaska district to the west. The rocks of the western area are much more irregularly distributed than in either the central or eastern section.

A.B. Pre-Cambrian.

In the early reports of the Geological Survey up to 1869, no Pre-Cambrian rocks were recognized in the Eastern Townships. The areas of crystalline schists, gneisses and limestones, with the serpentines and associated strata, were all referred to the several divi-

* A similar contact with the black slates is well exposed on the Bras stream about three miles up from the Chaudière River.—A. R. C. Selwyn.

Early views concerning the metamorphic rocks.

sions of the Quebec group, viz., the Levis, Lauzon and Sillery, of which the Levis was held to be newer than Potsdam, while the Sillery, in which a great variety of rocks were included, was considered the most recent, and these highly metamorphic rocks were supposed to be the equivalents of the two formations, Calciferous and Chazy, as developed along the south side of the St. Lawrence, their different aspect being due to an intense regional metamorphism which had affected the rocks of the Green Mountain range and of its extension into the province of Quebec for many hundred miles. In 1869, in the report of the late Mr. James Richardson on the country between the Chaudière River and Temiscouata Lake, the presence of an older series, composed of quartzites, slates and conglomerates, which were regarded as belonging to the Potsdam formation, was recognized. (See Geol. Survey Report 1866-69, p. 120.) No attempt was, however, made to trace these older rocks to the south-west of the Chaudière, and the remarks in the Report referred to do not appear to have been intended to apply to the area now under consideration.

First official publication regarding the existence of Pre-Cambrian by Dr. Selwyn 1877-78.

The first official publication on the part of the Geological Survey, in which dissent from the views expressed in 1863 was made, is found in the Geol. Survey Report 1877-78 (Dr. Selwyn) pp. 3 and 14 A, where it is stated that the crystalline portion of the Quebec group evidently belonged to a much older system than that hitherto assigned to it, and that, in part at least, it included rocks of Huronian and Lower Cambrian age, which were found to be non-fossiliferous, and were held to be distinct from the fossiliferous portion of the St. Lawrence area, which contained a fauna, apparently partly of Cambrian and partly of Cambro-Silurian age. The views here expressed were put forward in greater detail in the Transactions of the Royal Society of Canada, Vol. I., 1882 by Dr. Selwyn, and re-stated in the Geol. Survey Report for 1880-81-82, p. 2 A, as well as in his Descriptive Sketch, etc., 1884.

Subsequent papers.

As the change of views above mentioned has led to considerable discussion, a brief sketch of the structure of this portion of the province, as brought out by the examinations of the last two years, may here be presented.

General sketch of the structure.

Between the Maine boundary and the great plain of the St. Lawrence valley, which may be said to have its eastern limit at Athabaskaville, three prominent hill features are observed. Of these, the first, and most easterly, is seen in the height of land which constitutes the International line between the province of Quebec and the states of Maine and New Hampshire; the second is the Stoke Mountain range and its extension in either direction, and the third forms the broken and hilly country of Wolfestown, Chester, Tingwick and Shipton, which may be said to mark the prolongation in part, at

least, of the principal range of the Green Mountains, the most prominent part of which, after entering Canada from Vermont, is seen in Sutton Mountain, which attains an elevation of about 4,000 feet. These ridges indicate three well defined anticlinals, approximately parallel to each other, the intermediate synclinals being occupied by the Cambrian and newer rocks already described.

Three principal anticlinals.

The rocks of the eastern areas are described by Prof. Hitchcock in the Geology of New Hampshire, 1877, and indicated in the map accompanying that Report as belonging to his Lyman and Lisbon groups, and are held to be of Huronian age. They consist of tough, greenish granites, in places resembling a protogine, with talcose, chloritic and micaceous schists, fine grained gneissic granites and smooth talcose slates, which extend across the south-eastern portion of Quebec for some miles, occupying the south-eastern part of the townships of Emberton, Ditton, Woburn and Clinton, which lie to the south and south-west of Lake Megantic and the eastern portion of Ditchfield, and probably also a narrow margin in Spalding, although, owing to the unoccupied and inaccessible character of this area, the exact outlines are to some extent conjectural. Stratigraphically, they underlie the rocks of Ditton, which have already been described as of Lower Cambrian age, and like the slates and whins of the gold series of Nova Scotia. The reasons, therefore, for assigning these border rocks to a Pre-Cambrian horizon may be considered as fairly conclusive, but as much of the country is at present inaccessible, or so largely covered by drift, as to conceal the underlying strata, it is highly probable that limited areas of Cambrian and other slates may occur, especially in Woburn and Chesham, the outlines of which cannot now be mapped.

Lyman and Lisbon groups of Prof. Hitchcock regarded as Huronian.

Character and distribution in S. E. Quebec.

Relations to the Cambrian.

The anticlinal axis, seen in the Stoke Mountain range, and already alluded to in a general way, can be traced from the shore of Memphremagog Lake north-east past the city of Sherbrooke, where it is well exposed, and thence to Lake St. Francis. East of Lakes Weedon and Aylmer, it forms a ridge, with an elevation of 500 to 600 feet above the water of these lakes, and extends for more than twenty miles in length. The rocks are hard, flinty, greenish, white-weathering, felspathic schists, with talcose, chloritic and quartziferous slates. Near the summit of the ridge, on the road from Gould to Weedon, masses of granitic and dioritic rocks occur, as well as dolomitic schists, the whole presenting a marked resemblance to Huronian strata. The dolomitic portion is sometimes much decomposed, and on weathered surfaces is of a deep orange color. This ridge has a maximum breadth of about three miles on the road from Lake Aylmer to Stratford. It is separated from the mass of the Stoke Mountain range by the overlap of the Silurian lime-

Stoke Mountain anticlinal.

Ridge east of Lake Aylmer.

Small outcrop near Weedon church.

stones and slates of the Dudswell basin, but a small outcrop of gneissic and felspathic rocks, the debris of which enters into the composition of the overlying Cambrian conglomerates, is seen about half a mile north-west of Weedon church.

Stoke Mountain proper.

The principal mass of the Stoke Mountain range extends from the road leading from Dudswell Corner to North Stoke, southwest into the township of Ascot, with an elevation of 1000 to 1200 feet above the River St. Francis. It consists of hard gneissic felsite, granitic gneiss, hard felspathic schist, chloritic, talcose, and micaceous schist, with diorites. Through the township of Stoke it presents a serrated ridge, but approaching the St. Francis between Sherbrooke and Lennoxville, it rapidly sinks, and is apparently separated from another area on the south side of that river by a belt of black slates, probably of Cambrian age, which cuts across the range in a well defined depression. The ridge again appears on the south side of the St. Francis and extends south-westerly, attaining an elevation of 1000 feet above the river, on Lot 9, R. XI, of Ascot, just east of the Belvidere road, sinking thence to the foot of Lake Massawippi. Another prominent belt, known as Massawippi Mountain, extends for several miles along the west side of Massawippi Lake, with an elevation of 800 to 900 feet above its surface. This is also broken across at the upper end of the lake by the depression through which the road to Magog passes from Ayer's Flat, but immediately re-appearing under the local name of Bunker Hill, it continues with considerable persistence along the north side of Fitch Bay to Lake Memphremagog. Many of the schists in this area are highly nacreous, and they constitute the principal copper bearing belt in this direction. The axis in the chloritic and epidotic rocks is seen in the lower part of the Magog River, which flows through the city of Sherbrooke, whence it can be traced across the St. Francis into Ascot and Stoke.

Ridge south of Sherbrooke.

Massawippi Mountain.

Anticlinal at Sherbrooke.

The age of these metamorphic rocks is inferred from their general lithological character, as well as from the fact that they are apparently unconformably overlain by the Cambrian slates and conglomerates so well exposed in the neighbourhood of Lennoxville and in rear of Sherbrooke.

The Western or Sutton Mountain anticlinals.

The western division, concerning which most difference of opinion has arisen, is that which has been already referred to as forming the extension of the Green Mountain or Sutton Mountain range, the rocks of which, in Prof. Hitchcock's map of Vermont and in the accompanying sections, are described under the head of Green Mountain gneiss, and held to constitute the basal portion of all the formations in this direction, in this agreeing with Dr. Selwyn's determination published in 1877. In this map, the anticlinal structure of this complicated

Prof. Hitchcock's views.

area is well pointed out. As much of the confusion which exists as to the correct interpretation of the geology of this part of the Eastern Townships has arisen in connection with the structure of this range, the several opinions bearing upon it which have appeared from time to time may here be briefly stated.

The earliest mention of this mountain is found in Logan's Report for 1847–48, p. 52, where it is described as "standing between two anticlinals, which run into one, and might, therefore, be supposed to possess a synclinal form ; the strata were, however, observed to maintain dips, generally at high angles, in opposite directions from the axis of the mountain, with much constancy, on the Sutton and Potton, the Brome and Bolton and the Stukely roads, which the axis crosses, and the probability of this anticlinal form seems to be supported by one or two facts in Ely which require further examination. The anticlinal form of Sutton Mountain would appear to throw the two eastern belts of associated dolomites, soapstone and serpentine in Sutton Valley into the shape of a trough, and they would probably join northwardly a few miles beyond Stukely Mills." On page 53, it is also stated "that the rocks above described in connection with the Sutton Mountain anticlinal occur north-easterly to the Chaudière."

Early views as to the structure of the Sutton Mountain range, 1847-48.

In Geology of Canada, 1863, p. 251, while the same apparent general anticlinal of Sutton Mountain is described, it is stated that "it may include the whole or a portion of the Sillery sandstones, which, standing in an anticlinal attitude, would seem to have resisted or escaped the denuding forces that have worn out the valleys on the anticlinals of Sutton and Potton." On the hypothesis then advanced, that the Sillery formed the upper member of the Quebec group, the fact that the rocks supposed to be of this age constituted the apparent axis of this range could only be accounted for on the theory of a double inverted synclinal. In pursuance of this theory it is there stated that "the belts of magnesian rocks which are at the base of the mountain on its opposite sides, should in this structure be carried to a junction on the central anticlinal axis after turning on the synclinals which occupy the two flanks of the mountain, but though these belts have been traced northward for upward of twenty-five miles, their point of union has not yet been observed."

Views expressed in Geol. Can., 1863.

Though the area above described does not appear in the accompanying quarter-sheet map, the explanation of the structure above quoted is held to be important and almost necessary for a clear understanding of the stratigraphical relations of the various groups seen in the third area in the north-western portion of the map above referred to.

The theory of inverted synclinals, which is requisite to explain the

Probable lower position of the Sillery.

apparent lower position of the Sillery, becomes unnecessary if we regard the so-called Sillery as constituting the lowest member of the Quebec group, a supposition which appears to be fairly well sustained by the work of the last few years along the south side of the St. Lawrence, see Geol. Survey Rep. 1880–81–82, p. 31 DD., and still less so if we take the more reasonable view that the axis of the Sutton Mountain range is not composed of rocks belonging to any portion of the Quebec group, but rather to a much older series, either Lower Cambrian or Pre-Cambrian in age, as asserted by Dr. Selwyn since 1877 and in his various subsequent publications, enumerated page 6 J of the present report.

Views of Dr. Selwyn, 1877.

True anticlinal structure.

The latter view is also supported by the apparently regular anticlinal structure pointed out by Sir Wm. Logan in the reports quoted above, as well as by the lithological characters of the rocks which constitute the mountain range, and by the sequence of formations on either side. To the east, in the valley of the Missisquoi River, we find these metamorphic rocks in abrupt contact with those which comprise the volcanic group of Dr. Selwyn, and which are now described in this Report under the head of Lower Cambrian; this contact is marked by a line of fault, which undoubtedly represents many hundreds if not thousands of feet, while to the west there is an apparently regular upward sequence as far as Frelighsburg, near which place the rocks of the anticlinal are overlapped by sediments of lower Cambro-Silurian and possibly by those of upper Cambrian age.*

Great fault between the mountain series and the Cambro-Silurian.

Extension northward of the Sutton Mountain anticlinal.

The north-east extension of the Sutton Mountain anticlinal reaches the St. Francis River in the vicinity of Melbourne, whence it continues with a regular course to Danville. The relations of the various groups of rocks in this direction, as well as in the township of Ely to the south, are very obscure, owing to the presence of several faults, which have apparently brought the Cambro-Silurian fossiliferous strata into close proximity with those of much lower horizons. Near Danville, the anticlinal is deflected more to the east, and so continues to the vicinity of the line between the townships of Ham and Wolfestown, when it gradually resumes its more northerly and normal course. The axis is well seen near the village of North Ham; thence passing through the western part of Wolfestown, it crosses the township line of Halifax between Ranges I. and II., beyond which it has been traced by Dr. Selwyn, though not in detail, through Ireland to beyond the Chaudière River, which it crosses in the vicinity of Beauce Junction. The rocks of this area in Wolfestown and Chester are precisely similar to those seen on the road between South Bolton and Knowlton.

* See Section, Quebec Group in Geology, p. 12, Vol. I., Transactions of the Royal Society of Canada.

T. C. WESTON, PHOTO., 1873. IVES-PROCESS; G. E. DESBARATS & SON, MONTREAL.

PRE-CAMBRIAN CONTORTED SCHISTS,
RANGE VIII., LOT 15, SHIPTON,
QUEBEC.

In Shipton and in the southern part of Tingwick, the older rocks of the anticlinal are apparently concealed by the Cambrian and Cambro-Silurian sediments, which throughout Chester and in part of Wolfestown appear to occupy areas of considerable extent, superimposed upon the crystalline schists and kindred rocks after the manner of infolded basins. Frequently, an apparent conformity exists between the two series, the upper of which may possibly mark the southward extension of the rocks which were described by Mr. Richardson, Geol. Survey Rep. 1866-69, as probably of Potsdam age. Overlapping and infolded areas of Cambrian.

A fourth but limited area of Pre-Cambrian rocks occurs in the township of Garthby, and is well seen on the road leading from Sanborn to D'Israeli station on the Quebec Central railway. The rocks are greenish chloritic, and often highly micaceous schists, frequently with disseminated crystals of some greenish mineral, which has the aspect of chlorite. Talcose schists also occur in this belt, which has throughout a decidedly Pre-Cambrian character. It is surrounded by Cambrian sediments and is intersected by the dioritic and serpentinous masses which extend north from Big Ham Mountain. Pre-Cambrian of Garthby.

The areas which have just been described constitute the principal copper bearing belts of the Eastern Townships. Copper ores are found at many points throughout their whole extent; and in this respect as well as in lithological character they closely resemble the copper-bearing rocks which form the upper part of the Pre-Cambrian of New Brunswick and the Huronian of the Bruce Mines, etc. A very manifest similarity is also observed between these rocks and those which are now classed as Archæan in Scotland and England, and which by some authorities are held to constitute the upper members of the Pre-Cambrian, while by others they are regarded as forming the basal portion of the Cambrian system. They have been described, by Dr. Hicks, in Wales, under the names of Dimetian, Arvonian and Pebidian. Whatever may be the exact age of these altered rocks, their present aspect entitles them to be classed as very ancient sediments. And though, in view of the great alterations which may result from intense regional metamorphism, there is no reason why many of the ordinary sedimentary rocks of Cambrian, Cambro-Silurian or even Silurian age, should not assume much of the character of those just described, it is now tolerably clear that they constitute the lowest of all the geological formations encountered in this portion of the province. Copper-bearing rocks. Their similarity to the Archæan of Scotland and England.

Crystalline and Igneous Rocks.

Plutonic and Volcanic.

Granite.—The granites of the area under consideration have been referred to in previous reports. In 1847–48, attention was directed to

them by Sir Wm. E. Logan, as being particularly adapted for building stone. Later, in 1849–50, their intrusive character was pointed out, and the position of the principal masses given. The statement was at that time advanced that these rocks might constitute a chain of hills extending from Lake Megantic to Bathurst on the Bay of Chaleurs, a hypothesis not, however, supported by later investigation. In the Geology of Canada, 1863, attention was also directed to the presence and distribution of these rocks, and their intrusive character, indicated by their mode of occurrence and their action upon the surrounding strata, are clearly pointed out, (see pages 430, 434.) On page 452, where a comparison is made between the granitic rocks of New Brunswick and those of the Eastern Townships, Maine and Vermont, it is suggested that all these granites are probably contemporaneous in age. The statement, however, that these rocks in the Eastern Townships intersect the Devonian strata, and that, as a consequence, they belong probably to the close of that period, must here be corrected; since the rocks which were then held to be Devonian, viz., the black graphitic limestones and mica schists of the east side of Memphremagog Lake, and the area lying to the east, have been now found to belong to older systems, and to be in part at least, Cambro-Silurian. There is, therefore, nothing in this part of the Townships to indicate any age for the granites later than the close of the Silurian, since they are not seen at any point to penetrate strata of later date. They differ somewhat from the granites of New Brunswick in composition and color, those of the latter province, for the most part, being reddish, while the Township granites are generally white. Their intrusive character is, however, clearly defined, not only by the metamorphism of the slates and limestones in contact, but by the number and character of the veins and dykes which, issuing from the principal mass, penetrate the surrounding sedimentary strata and ramify in all directions.*

Early views relating to the granites.

Compared with similar rocks in New Brunswick.

Six principal areas recognised.

The principal granitic areas are six in number. Of these, the most southerly is in the townships of Barnston and Barford, where it marks the northern limit of the great granite mass of northern New Hampshire, well seen in the hills on either side of the Grand Trunk railway to Island Pond. Its most prominent feature in Canada is the Barnston Pinnacle. It extends along the boundary for some fifteen miles, terminating eastward at Little Leach Pond and occupies the greater part of the two first ranges north of the province line. The rock is generally white, composed of quartz, white orthoclase

Barford and Barnston.

* I hold that there is nothing whatever in the mode of occurrence of these granites which certainly proves them to be intrusive in the ordinary acceptation of that term. They are more probably formed *in situ* by the same metamorphic agencies that have altered the adjacent strata, and the so-called dykes are probably due to segregation; in fact the latter are rather veins than dykes. See Report on Nova Scotia Lower Cambrian rocks, Part P.—A. R. C. SELWYN.

and black mica. At the contact with the slates, it becomes finer in texture, a feature also frequently noted in connection with the granites of New Brunswick. Alteration at the contact with the slates.

Further west, similar granites appear in Stanstead township in limited outcrops, and occur at intervals to the shores of Memphremagog Lake. Stanstead. The principal outcrop is seen on Range IV., V. and VI., lots 1 to 5 inclusive, where, however, much of the highly altered slate and limestone is intricately involved with the granite. Near the extremity of Magoon's Point also, on the shore of the Lake, a small outcrop penetrates black, irony slates, presumably of Cambrian age, producing staurolites or kindred minerals. These granites have been worked for building-stone, the quality of which is excellent. A somewhat remarkable dyke of this rock is seen a short distance west of Stanstead village, extending for about four miles with the bedding of the enclosing slates, and with an exposed breadth of twenty-five to forty yards. In the vicinity of Barnston Corner also, two small Barnston Corner. outcrops are noted, the first, and smaller, about three-fourths of a mile west of the village, with an exposed breadth of forty yards, constituting a knoll in the Cambro-Silurian slates and limestones, the other about one mile east of the Corner, as a broad dyke, running with the bedding of the slates and limestones for a distance of over a mile, and crossing the road from Barnston to Coaticook. The action upon the sedimentary beds is distinct, crystals of mica and chiastolite being produced in the adjacent strata. Further east, in Barford and Hereford, other limited Hereford. areas are found and are indicated on the map. From the frequency of the outcrops, however, and the generally altered condition of the various rocks in this direction, it is probable that the granites may underlie, at no great distance, a great part of this portion of the province, appearing only where exposed by denudation.

To the north, the next granitic area is that known as the Great Megantic Mountain, Great Megantic Mountain. situated near the corner of the townships of Hampden, Marston, Ditton and Chesham. The granites of this locality, which form a lofty range of hills extending some nine miles, with a maximum breadth of four miles, are similar in character to those of Barnston already described. The Megantic Mountain area is separated by slates and sandstones from a third considerable area, seen at Scotstown, Scotstown. on the International railway, whence it extends eastward on that line for about three miles, and north-westward for a like distance. The action of the granites on the slates is here also well defined by the presence of mica and chiastolite crystals, and a gneissoid texture Chiastolites. is imparted to the sandstones. The country occupied by this area is generally low, and the exposures are comparatively few, patches of slates being intermixed with the intrusive rocks.

A fourth range of hills is seen in Whitton and Gayhurst, of about the same extent as the Victoria range, known locally as the Little Megantic Mountains, while a fifth area occupies the greater part of the country lying between the road leading from Stratford to Stornoway and the upper part of Lake St. Francis, where, along the Felton River and the several lakes of that section, prominent granitic peaks are seen. The rock here occurs also frequently in the form of dykes of all sizes, mixed with altered gneissic sandstones and slates, the separation of which in the swampy and barren country about the lakes is for the most part impracticable.

Little Megantic Mountains.

Further to the west, about midway on Lake St. Francis, a dyke of granite appears on either shore; on the west side, having an exposed breadth of thirty yards only, cutting slates of Cambro-Silurian or Cambrian age, while on the east side, it has a width of several hundred yards. It, however, does not apparently extend to any great distance inland, the country in the vicinity being generally low and the exposures confined to low-lying ledges on the beach.

Lake St. Francis.

The only remaining area of granite of considerable size is that in the township of Ditchfield, about the upper part of Lake Megantic. Spurs, presumably from this mass, show on the west side of the lake, on the road between Ranges I. and II., Lot 2, Marston, where slates of purple tinge are altered to a highly chiastolite-schist. Other dykes occur on the shore of the lake on either side of Moose Bay, but do not extend far inland. The northern margin of the principal area, which is on the east side of the lake, is seen on the road which extends between Ranges II. and III., Ditchfield, on Lot 30, where beds of grey and purple slates, are altered to highly metamorphic schist, filled with chiastolite, for a distance of nearly half a mile from the contact. Granite rocks thence occupy the country in the vicinity of Spider Lake, though much of the surface being swampy, ledges are not frequently exposed, and it is probable that schistose slaty rocks are here to some extent, intimately associated with the volcanic series. They apparently extend across the boundary into Maine, where they are displayed about the head waters of the Dead stream. They are also seen in the high hills of eastern Woburn and Chesham, the surface in this direction being generally very rugged and broken.

Ditchfield.

Chiastolite-schist.

Spider Lake and vicinity.

To some extent, the outlines of the granite masses are of necessity conjectural, since large portions of the surface are covered with drift, over which, however, granite boulders are thickly strewn.

While it cannot be definitely stated from the contacts of the granite with the associated rocks in this portion of the province what the precise age of their intrusion may be, since in no case are they associated with strata newer than Cambro-Silurian, yet it may be inferred

to be not far from the close of the Silurian period. Certain areas of granitic rock, however, seen in the Stoke Mountain range and at several other points, are clearly older, since their debris is found abundantly in the conglomerates of Cambrian age already described. Their character and composition also differ very widely from those of the granites just described. Probable age of the granites.

While there is, apparently, no doubt as to the intrusive nature of much of these rocks, no indications are seen to warrant the hypothesis that such intrusion was attended by any great disruptive force, by which the overlying strata were thrust asunder to such an extent as is now occupied by the granitic masses. It appears more reasonable to suppose, that the great bulk of these granites have risen quietly from below, and in their ascent have eaten away, or incorporated in their mass, the various strata with which they came in contact.* This theory is supported to a certain extent by the frequent outcrops of these rocks, which would seem to indicate their presence at no great depth, over a very large part of this area, as well as by the fact that no change occurs in the strike of the various beds on either side, even of the largest intrusions. Where local deflections of strata are found, they are more often in connection with smaller outcrops, and may sometimes be referable to other causes. The alteration of the surrounding sediments extend with great uniformity in all directions from the granitic masses. Disruption of the contiguous strata is, however, seen along the borders of the large areas, in the presence of dykes or veins, ranging in thickness from mere threads up to several feet, which intersect the strata, sometimes along the bedding planes, and at times forming a perfect network. Their mode of occurrence. Intersecting dykes or veins.

Diorites.—Dioritic rocks are found at many points throughout the Townships, sometimes in masses of large extent, as in the Big and Little Ham Mountains, and in the peaks along the western side of Lake Memphremagog; at others, as bosses and dykes. With these are often associated dioritic agglomerates, serpentines and serpentinous breccias. The largest and most important areas are found in a belt which can be readily traced from the Vermont boundary, north-east for over one hundred miles, crossing the Chaudière River, and extending into the townships of Cranbourne and Ware. Dioritic rocks.

Throughout the greater part of this area, the dioritic rocks are intimately associated with the quartzites, quartziferous schists, and black, red and green slates, which are now described under the head of Cambrian. To the south-west, the most prominent features are Hawk, Bear, Owl's Head, Sugar-loaf, Elephantis and Hogs-back

* This is not intrusion in the ordinary acceptation of that term, but rather the metamorphic process referred to. See Note page 36 J.—ALFRED R. C. SELWYN.

Dioritic peaks of Lake Memphremagog and vicinity.

Mountains, some of which may mark the sites of extinct volcanoes. These hills are situated near the west side of Lake Memphremagog, south of Sargent's Bay; and about four miles due north-west from the foot of Mémphremagog Lake, are the great masses of dioritic and serpentinous rocks which form the Orford or Victoria Mountains. The central portion of the belt is marked by two prominent hill masses, called the Little and the Big Ham Mountains, the outlines of which are almost identical, and further east, about four miles north of the foot of Lake St. Francis, is another huge cone-shaped peak, resembling the Owl's Head to the south. This readily seen for many miles in all directions, and is known locally by the names Bull Mountain and Owl's Head. The Ham Mountains apparently divide this belt into two areas; the south-western portion is occupied by smaller outcrops of volcanic rocks, seen in a number of hills, some of which are of small extent, in the vicinity of Brompton, Long and Orford Lakes, where dioritic and serpentinous rocks are closely associated. Two somewhat parallel bands of these rocks apparently exist in this area; the most westerly being seen in the serpentinous and dioritic masses of Melbourne, Cleveland and Shipton, where the former portion apparently ends, the diorites being continuous, however, to the Little Ham Mountain; the other, that seen about the Brompton Lakes, where it has a somewhat extensive development, and continues in the direction of Windsor Mills.

The Ham Mountains.

General course of the volcanic belt.

The course of the principal belt is generally north-east, following the prevailing trend of all the formations; but in Cleveland and Shipton, it assumes a transverse twist which also affects the Pre-Cambrian and other formations in the vicinity, and changes the strike for some miles in the townships of Wotton and Ham to an almost easterly course. The prolongation of the Melbourne and Shipton ridge, which apparently terminates at the Little Ham Mountain, after an interval of about five miles, occupied by slates and sandstones, re-appears in the Big Ham Mountain, which is on Lot 2, Range XI., Ham, and rises boldly, from the somewhat flat country around its base, to a height of 1150 feet, forming a magnificent hill feature in the landscape. Thence the diorites extend with a gradually curving outline to the north-east, crossing the road from South Ham to Garthby, and continuing through the latter township, as well as the eastern part of Wolfestown, Coleraine and Thetford, where it is conspicuously marked by the large elevation of the Bull Mountain already noted, which is near the junction of the townships of Adstock, Thetford and Coleraine. As in the Brompton belt, diorites are more prominent at the extremities, while the central portion is characterized by the presence of serpentines, which in this direction have a great develop-

Big Ham Mountain.

Extension to the north-east.

ment, especially in Coleraine and Thetford, with some large areas in Wolfestown, now of great importance as the seat of the asbestus industry, which will be described in greater detail under the head of Economic Minerals.

Smaller areas of dioritic rocks are numerous. Of these, probably the most important is seen in the township of Ascot, where it traverses the area of the copper-bearing schists, extending from Lot 19, Range V. of Ascot, south-westerly at intervals to Lot 27, Range IV., Hatley. This belt has a considerable development in the vicinity of some of the copper mines, situated to the south of Sherbrooke. Diorites, of more limited extent, occur also on the line between Westbury and Stoke, but these are of comparatively recent age, since they have altered the slates with which they are in contact. Dioritic rocks of Ascot.

In the Megantic area in Clinton, Chesham and Emberton, dioritic masses are also seen. Two prominent hills are noted, the one on Lot 10 and 11, Range I. and II., Clinton, the other on Lot 25 and adjacent, Range VII., Clinton. They are apparently part of the chloritic slate series, and may belong to an earlier date than many of those of the central and western area. It is probable that the diorites of the several localities have come to the surface at widely different periods, for while some have manifestly exercised a metamorphosing action on the Cambro-Silurian strata, at other places, the lower beds of the Cambrian are largely made up of their debris. Diorites near the Maine boundary.

Serpentine.—The mode of occurrence, origin and distribution of *serpentines* have been fully discussed by Dr. Hunt and others, and a variety of opinions have been expressed respecting them. The serpentines are of various shades and colors, frequently associated with magnetic and chromic iron ores but they are chiefly of importance from containing at many points, in workable quantity, veins of chrysotile or fibrous serpentine. Within the last few years, these have been profitably worked, and asbestus mining now bids fair to form one of the leading industries of the province. Serpentines.

Throughout the greater part of the volcanic or dioritic belt already described, these serpentinous rocks occur at intervals. To the south-west the most important areas yet recognized are in the vicinity of Orford Mountain and lake, and about Brompton and Long Lakes. An extension of this belt is seen, on Lots 12-13, Ranges IV. and V., Brompton, and this is apparently the northern limit of thse rocks in this direction. Their distribution.

The south-western belt is largely developed in the townships of Melbourne and Cleveland, and extends into Shipton and Tingwick. In the former township it is well seen at the Melbourne slate quarry, where it is brought into contact with the slate by a fault. Thence it can be traced The south-western area.

with considerable regularity to the St. Francis River, crossing which it re-appears on Lot 6, Range XV., Cleveland. It is here intimately associated with hard quartziferous schists and slates. Further north, the prolongation of this belt is seen on Lot 9, Range XV., of this township, as well as at several points midway. It again re-appears at the five roads on Lot 9, Range III., of Shipton, now known as Asbestus P. O., in a small knoll, in which the asbestus mine worked for some years by Mr. Jeffrey, of Richmond, is situated. It again re-appears on the road to Wotton on Lot 7, Range II., and on the south-west shore of Lake Richmond, on Lot 27, Range X., Tingwick. The last outcrop now known in this direction is on a branch of Trout Brook, and was reported by Mr. A. J. Morrell, of Danville, as occurring on Lots 21-22, Range XI., Tingwick.

Asbestus.

Massawippi Mountain and vicinity.

In the vicinity of Massawippi Lake, outcrops of serpentine are found in the Hedge-Hog Mountain, Lot 15, Range VI. and VII., and in small areas on Lot 11, Range VI., Hatley. Serpentines, associated with soapstone and diorites, are also found on Lots 19-20-21, Range V., near the shore of the lake, the soapstone being apparently of excellent quality. They occur in what is probably the south-west prolongation of the metamorphic belt of the Ascot copper mine. Similar limited outcrops are found along the road from North Hatley to Capelton, on Lot 26, Range II., and Lot 27, Range I., Hatley.

Hatley.

North-eastern area.

The most important area of these rocks is that which, terminating southward in Big Ham Mountain, extends north-easterly to and beyond the Chaudière River. In this belt, serpentines are first seen in several hills on the south side of the outlet of East Nicolet Lake and on the west shore, where, on Lots 19-20 of the Gore adjoining Range XI., a vein of magnetic iron ore is seen, having a thickness of six feet at the surface, and is said to increase to eleven feet in the shaft at a depth of twelve feet. About 100 tons of ore have been taken from this vein. The serpentine here is dark green in colour, and is said to contain a small quantity of grey copper ore. According to Mr. Coulombe, who first opened this mine in 1881, the serpentine extends south-west from this point to near the foot of the Ham Mountain, on Lot 16, Range XI., Ham. It occupies also all the islands in the lake and the south and east shores, extending in a ridge towards the road leading to Garthby village.

Iron ore of Nicolet Lake.

Soapstone.

On the south end of the lake a considerable area of soapstone is seen on Lot 22, Range I. (old numbering 43-44), owned by Mr. E. Clark, of Sherbrooke. A similar deposit is found on Lot 25 (old numbering 49-50), Range II. The principal mass of the serpentine stops on Lot 55, though the mineral is found associated with the diorites on the Garthby road.

To the south-west of Breeches Lake, serpentine again forms a prominent ridge, reaching the shore of the lake, and appearing also in several islands in that sheet of water. The north end of this lake is apparently occupied by dioritic rocks, which here have a breadth of about two miles, but on Ranges IV., III. and II. of Wolfestown, a prominent ridge of the serpentine appears and comes to the road leading from Wolfestown to Coleraine station. On the north-east flank of this ridge on Lots 23 and 24, Range II., the asbestus mines of Belmina are situated. The serpentine here is associated with considerable masses of whitish granulite, a rock composed principally of felspar and quartz, but in places, from the addition of mica, becoming a true granite. This appears in places to cut the serpentine after the manner of true dykes, and to its presence may possibly be ascribed some of the frequent faults which affect these rocks and which are disclosed in the asbestus workings. The opinion is also held by some of the managers of the asbestus mines that the presence of these dykes affects favorably the quality and amount of the asbestus. Breeches Lake. Belmina mines. Granulitic rocks.

Crossing into the adjoining townships of Ireland and Coleraine, the serpentine forms a very rugged country to the west of the Quebec Central railway, the bold and rugged peaks and ridges, as seen to the south-west of Black Lake, constituting very prominent features in the landscape. These ridges take their rise a short distance north of the boundary between Ireland and Wolfestown, and extend thence, apparently without any serious break, into the township of Thetford. In the eastern part of Coleraine also, in the vicinity of Caribou and Little St. Francis Lakes, several hills, occupying a considerable area, are found. The further extension of this belt northward has not yet been traced, the country being for the most part unopened and in places thickly wooded. In the vicinity of Black Lake station and between this point and Thetford, the serpentine is largely intermixed with white weathering granulite, and in so far as yet known, this area constitutes the richest asbestus ground in the province. Throughout all these localities the serpentine presents generally a massive appearance. No indications of banding or interstratification were observed at any point, with possibly the exception of a very limited outcrop seen on Lot 16-17, Range II., S. E., Garthby. It is presumable that in most cases at least the rock is to a great extent an alteration product of some form of dioritic rock, rich in olivine, as already pointed out in reference to the serpentines of the Shickshock range by Dr. Harrington and Mr. F. Adams. See Geol. Survey Report, 1882–83–84, pp. 19–20 F. Black Lake. Caribou Lake. Granulite. Garthby. Origin of serpentine.

Throughout the whole of the serpentine areas indications of asbestus are found, the veins ranging from mere threads up to four and even six inches in length of fibre. The rock is often affected by faults, Asbestus.

which are well seen in the asbestus workings, and which cut off the mineral veins in the same way as faults in ordinary sedimentary strata affect mineral lodes. This feature will be further considered in the remarks on asbestus.

Superficial Geology.

While it has not been possible, in the time at our disposal, to make any very exhaustive study of the superficial geology of this district and the various phenomena in connection therewith, some attention was paid to the distribution of the drift deposits, more especially with a view to determine their connection with the auriferous character of much of the sand and gravel, which occur over a very large area. Wherever glacial striæ were seen, their direction was carefully taken, though in many cases it was impossible to determine, especially in a flat exposure, in what direction the ice had passed. Conditions similar to those which have been described as affecting the distribution of glaciers in Gaspé and Northern New Brunswick (see Geol. Survey Report GG, Mr. Chalmers, 1882–83–84 and 1885), will probably be found to have prevailed to a large extent in this area.

Distribution of fine gold.

The source of the drift possesses considerable importance when we consider that in nearly every brook or stream throughout the Eastern Townships from the Chaudière to the Vermont boundary, traces of gold can be obtained in almost every pan of gravel washed. It is also found in the country lying to the north-east of the Chaudière, but its limit in that direction has not yet been determined. At several points also in connection with the Central ridge, more particularly at Dudswell, Stoke, and Little Magog Lake, indications of the precious metal have been found, but it is not yet known to exist in quantity sufficient to yield profitable returns to ordinary mining.

Theory of the universal ice sheet considered.

The theory of a universal ice sheet of many hundreds of feet in thickness does not now appear to meet with much support as applied to this region. Proceeding south-east from the St. Lawrence basin, three principal ridges, already described, with elevations from 1000 to nearly 4000 feet above the sea, would have to be surmounted, which would require a propelling force imparted to the glacier, the source of which cannot be found in any great continental elevation related to the St. Lawrence Valley. The great diversity also observable in the direction of the striæ at different points would appear to be opposed to this theory, for over a great portion of the eastern Cambro-Silurian area, there is a general course either to the south-east or north-west. If we accept the former course as that in which the ice passed, we must explain the manner in which the ice sheet overcame the gradual ascent from the valleys of the Massawippi and St.

Objections to the theory.

Francis Rivers, which have an elevation of 550 feet above the sea level to the height of land on the Maine border, which reaches an elevation of from 1800 to 3800 feet.

The theory which ignores for the most part the existence of the great continental ice sheet, pre-supposes the presence of local glaciers which formed along the summits and crests of the principal mountain ranges, from which the ice descended in either direction, influenced largely by existing topographical features. Theory of local glaciers.

Since there is strong presumptive evidence to support the view expressed on previous pages, that the probable source of the gold of the Townships is largely in the areas of Cambrian slates which flank the old ridges of the boundary and the central axis, we may briefly consider what effect the application of the local glacier theory would have upon the present known distribution of the alluvial gold of this section.

On this view, these local glaciers would be shed on either side from the great mountain ridge along the Maine and New Hampshire boundary. The character of the drift in Northern Maine has not yet been closely worked out, but on the Canadian side it is evident that the debris, resulting from the disintegration of the Cambrian gold-bearing slates, would be carried north-westerly and distributed generally over the great Cambro-Silurian area of Compton, Stanstead and Beauce counties. This view is also sustained by the direction of the glacial striæ where visible; since on the south-eastern slope of the boundary chain, we find the course of the ice to have been S. 65° E., directly down the mountain, while on the Quebec slope, the course is N. 65° W., or directly opposite, the bearings being given with reference to the true meridian, with an assumed variation of 15° W. A general north-westerly course is also observed about Lake Megantic as well as further south in Ditton and Emberton. In Hereford, along the lower part of the valley of Hall's stream, only one observation was taken, where the course was S. 20° E. in the direction of the stream, and may indicate the existence of a local glacier which passed southward along the valley of the Upper Connecticut River. Effect of the action of local glaciers on the auriferous drift. Courses of the glacial striæ.

To the north, on the Chaudière at St. George, and in Risborough on the Du Loup, a general direction of N. 55° W. was found all along the course of these streams, the descent from the boundary on the Kennebec road to the forks of the Du Loup and Chaudière being about 1200 feet by aneroid.

We may, therefore, infer with some show of reason that a glacier of considerable extent descended from the height of land in this direction westward. It is very doubtful, however, if this surmounted the 1000 or 1400 feet elevation south of Sherbrooke and in the Stoke Direction of glaciers.

Striæ on Massawippi Lake.

range, since on the east side of this ridge, between Fitch Bay and Massawippi Lake, we find striæ on the south side of the Bunker Hill ridge, apparently descending towards the Massawippi valley. To the north, however, in the considerable depression between Lennoxville and Richmond, through which the St. Francis flows, the course of the striæ would seem to indicate that a part of the main glacier at least passed in this direction, the direction of the markings being in the line of the valley.

Memphremagog Lake.

In the vicinity of Memphremagog Lake another set of striæ are seen, which appear to indicate the presence of a local glacier which proceeded from the volcanic chain, marked by the great masses of Hawk and Bear Mountains, the Owl's Head, and Elephantis; the markings on the rocks along the side of the lake would indicate a passage of the ice in a northerly direction, the courses ranging from N. to N. 25° W., following the outline of the lake itself, and possibly continuing northward to join the main stream down the valley of the St. Francis.

Stoke Mountain range.

Along the west side of the Stoke Mountain also, the principal striæ have a north-westerly course towards the valley of the Wattopekah River, while in the country south of and in the vicinity of Ham Mountain the striæ have a south-east course on the west side and a south-west course on the east side of that elevation, as though the ice streams were converging into the same valley, and thence would join the main St. Francis valley stream in the direction of what is now Windsor Mills.

Lake Aylmer.

Farther to the north, in Garthby and Lambton, the markings also indicate the passage of the ice sheet from the higher lands of the volcanic belt into the depression of Lake Aylmer. These may mark the existence of very local glaciers of small size. The striæ noted in the valley of the St. Francis, east of D'Israeli station, would lead to the inference that the ice followed generally the depression of this stream, but as a large part of the surface is now thickly covered by drift, the striation cannot be traced for any distance.

In connection with this branch of the subject, the following list of striæ, noted principally during the summer of 1885, is here presented, the bearings being corrected to the true meridian, the variation being assumed as 15° west and north:—

List of striæ.

Localities.	
One mile west of Lennoxville, on road to Sherbrooke	N. 25° W.
North side of St. Francis River, one mile east of Sherbrooke	N. 35° W.
Road half a mile west of Wilson's Mills	N. 60° W.
Two miles west of Barnston Cor., on road to Ayer's Flat	West.
Cor. of roads S. W. end of Massawippi Lake	N. 20° W.

Two miles S. W. of Massawippi Lake on road to Fitch Bay...S. 25° E.
Top of ridge, one mile and a half north from Magoon's Point, on road to Georgeville ....N. 30° E.
On road one mile south of Georgeville.........................N. 5° W.
Two miles south of Georgeville, on road to Fitch Bay........N. 15° E.
Head of Fitch Bay ....S. 25° E.
Half a mile north of Fitch Bay P. O., on road.................S. 5° W.
One mile and a half east of Magog, on road to Ayer's Flat....N. 5° E.
Road to Sharon's Mine..N. 5° E.
West side of Massawippi Lake ....N. 15° W.
Cor. of Magog Road, on road from Ayer's Flat to Kateville...N. 5° W.
Road west of Sherbrooke, in rear of Brompton Falls..........N. 65° W.
Road up hill south of Lennoxville, half a mile from town....N. 35° W.
Road half a mile north of Stoke Lake—two sets....S. 80° W., N. 60° W.
Half a mile south of Cookshire, on road to Eaton..............N. 35° W.
Road through Newport, two and a half miles east of Island Brook P. O..N. 50° W.
Road crossing on line between Ditton and Emberton........N. 55° W.
Boundary line overlooking Lake Sophy.........................N. 45° W.
Lot 49, Range VII., Ditton.......................................N. 55° W.
Half a mile west of Chartierville P. O., Emberton.............N. 55° W.
North-west side Memphremagog Lake, near outlet...........N. 5° W.
Four miles north of Sherbrooke, on road to Ascot.............N. 55° W.
Road between Brompton and Ascot, four miles west of Sherbrooke...N. 30° W.
Brompton and Orford line, six miles west of Sherbrooke.....N. 30° W.
Four miles north of Sherbrooke, on road to Stoke Centre......N. 65° W.
Corner of road, Lot 3, Range II., Ascot.......................N. 20° W.
Compton Village..N. 50° W.
Two miles east of Coaticook, on road to Hereford.............N. 35° W.
Valley of Hall's Stream, Hereford..............................S. 20° E.
One mile south of Ascot Cor., on road.........................S. 60° E.
Road through North Stoke, Range XIII.........................N. 75° W.
Road from North Stoke to Ste. Camille, near small Lake.... N. 35° W., N. 53° W.
Road Ste. Camille to South Ham, ¾ mile south of Ham village N. 65° W.
Near Ham Court House—two sets..................S. 75° W., S. 30° E.
Three miles north of Ham Court House........................S. 75° W.
Ham Corner...N. 60° W.
Two miles west of Big Ham Mountain, road going south......West.
Road through Range XI., Tingwick.............................S. 60° W.
Ste. Camille, near corner.......................................S. 15° W.
Half a mile north of Ascot line, on road to Stoke.............N. 40° W.
Road, Lot 9, Range VI., Melbourne............................N. 50° W.
Road Ham to Shipton, at crossing Middle Branch of Nicolet River...N. 25° W.
Road Ham to St. Adrien, Lots 5 and 6..........................N. 5° W.
Road on ridge north of Victoria Bay, west side of Lake Megantic..N. 50° W.
Three miles east of Maine boundary, on International railway..S. 65° E.

International railway, eight miles east of Agnes	N. 65° W.
Wolfestown, road through Belmina, Lots 13–24, Range II.	N. 75° W.
Road Dudswell to Ste. Camille, Lot 26, Range X.	West.
Road Marbleton to Ham, four miles south of Ham Corner	West.
Ste. Camille, Lot 35, Range II.	West.
Ham, Lot 24, Range IV.	S. 80° W.
Road one mile west of Garthby station	S. 65° E.
Quebec Central railway, one mile and a half south of Coleraine station	S. 60° E.
Crossing of St. Francis River, D'Israeli station	S. 10° E.
Road D'Israeli to Lambton, two miles east of station	S. 5° W.
Forks of road, Lambton to St. Romain	N. 30° W.
Road from Lake St. Francis to St. Romain	N. 65° W.
St. Romain Corner	N. 65° W.
Stornoway Corner	N. 75° W.
Victoria range road, half a mile south of railway	N. 60° W.
Silver Mine, Risborough	N. 60° W.
St. George, Beauce	N. 55° W.

Marine beds absent.

Through the whole area under consideration, no traces of marine beds were observed. Allowing the amount of subsidence at Montreal to range from 470 to 500 feet, if we suppose this to have been uniform for the St. Lawrence area, the part submerged would probably be bounded on the east by the high ridge beginning at Arthabaska and extending to the south-west, and embracing the great stretch of level country lying to the east of the St. Lawrence.

Sand and gravel drift.

Deposits of blue clay are found along the valleys of some of the streams in the higher lands of the interior, at levels of 500 to 1,000 feet above the sea, but these are all apparently of fresh water origin. Large quantities of sand and gravel drift are also found along the course of the principal rivers, as along the St. Francis between Lake Aylmer and Lennoxville, and lower down between Sherbrooke and Melbourne. These are well seen for a few miles on either side of Windsor Mills, where they form large conical or ridge-shaped hills, having elevations of fifty to a hundred feet above the present flood plain. Great quantities of sand drift are also found in the vicinity of Danville, and along the depression toward Warwick. On the International railway, east of Lennoxville, several deep cuttings in stratified gravels and sand are seen at a height of about 300 feet above that town, and on the road between Brookbury and Robinson, a short distance west of the latter place, a well defined kame is observed having a north-westerly course.

Boulder drift.

In the townships of Clinton and Woburn, considerable areas are thickly strewed with granite boulders, which have presumably been derived from the great granitic mass of the boundary, lying to the south-east of Lake Megantic, indicating a north-westerly movement. On

the road also through Whitton, between the foot of Lake Megantic and St. Romain, granite boulders are distributed on either side of the range of the Little Megantic Mountains, while in Marston and Hampden, along the old Megantic road, similar boulders are abundant, which have evidently proceeded from the Victoria Mountain chain. Whether the presence of the gold found so generally distributed over the great Cambro-Silurian area between the central and the eastern ridge, and which is, for the most part, in a very fine state of division, is due to glacial action or to pre-existing causes, is at present, to some extent, at least, an open question. In the Cambrian belts, however, nuggets of good size are found, and much of the gold is coarse. The same coarse character is reported at several points on the eastern slope of the central axis, and is also observed in much of that obtained from the Gilbert, and adjoining tributaries of the Chaudière River. Upon the view of the structure already stated in previous pages, that the ridge between this stream and the Famine, is of Cambrian age, and the presumed equivalent of that found along the eastern boundary, this peculiarity can be easily explained, since this area would then probably prove to be the source of the gold.

Character of the drift gold in the eastern Cambro-Silurian area.

Coarse gold.

The presence of old river valleys has of late been recognized in connection with several of the streams which flow into the Chaudière, though no attention has as yet been directed to the finding of these ancient channels, except in that district. Among those known to exist may be mentioned that of Slate Creek, at St. George, now being worked, the Famine, and the Gilbert, and on the opposite side, the Pozer stream, with presumably some portions of the Chaudière itself. These channels, judging from that already opened on Slate Creek, are many feet below the present level of the stream, and it is from these that the greater part of the gold yet obtained in this district has been taken.

Pre-glacial river valleys.

By the kindness of Mr. A. A. Humphrey, Manager of the St. Onge Gold Mining Co., the following statement of strata, passed through in the last shaft sunk on the old channel of Slate Creek, is here presented:

Section of drift at Slate Creek, Beauce.

	FEET.
Boulder clay, boulders, both native and foreign	40
Sand	2½
Boulder clay	20
Stratified clay, without pebbles	60
Quicksand, small pebbles and fine gold	40
Sand and gravel, containing gold in quantity, often coarse	4
	166½

It is evident from the above table that these old channels had not only been excavated, but had been partly filled up, and the streams

diverted to their present courses, long prior to the glacial action by which the boulder clay was distributed. It would also appear from the lack of gold in the boulder clay, and from its presence in the underlying and more ancient sands and gravels, that the causes which were principally instrumental in the formation and distribution of the alluvial drift, over the greater portion of the Cambro-Silurian area, were distinct from those which strewed the surface so thickly with granitic and other boulders, and that they preceded the latter by a very considerable interval of time.

Distribution of drift.

Character of soils.

While the character of the soil is to a large extent dependent upon the nature of the underlying rock, certain causes may at times intervene, by which the superficial deposits that arise from simple disintegration of the strata may be affected favorably or otherwise. These causes are principally two in number, viz., the subsequent effects of glacial action in some form, or the redistribution of surface material by the action of water, either marine or fluviatile. Since it has been shewn that no traces of marine action exist in this part of the province, whatever changes have taken place as regards the distribution of the original surface soil, must be due either to the latter cause or to the agency of land ice.

As a rule, the most fertile soils are found to be made up of the disintegrated calcareous strata of the great Cambro-Silurian basin. A similar degree of fertility should also characterize the portion underlain by Silurian sediments, but for the fact that the principal area, which is found on the St. Francis River, north of Dudswell, has been covered subsequently by a considerable thickness of alluvial sand and gravel. In the areas occupied by the more sandy sediments of the Cambrian, and by those of the older metamorphic rocks, though good soils are found at intervals, such areas are generally limited, and their fertility is, in many cases, due to other causes than the decay of the immediately underlying rocks.

Character of soil as affecting settlement.

The difference in the nature of the soil is also very clearly shewn by the character and distribution of the various settlements. Thus in the townships which extend for some ten to fifteen miles east, from the central metamorphic ridge, embracing the western portion of the counties of Compton and Stanstead, where the limestones are more particularly developed, the country is intersected in every direction by roads, and flourishing villages are numerous. Here also some of the most famous farms in Canada are situated, among which may be mentioned that of the Hon. J. H. Pope at Cookshire, that of the Hon. Senator Cochrane at Compton, and that of Mr. Pierce, near Stanstead Plain. The eastern part of these counties, with a large proportion of Beauce adjoining, though of late years beginning to be opened up, is yet

largely a wilderness; the soil, as a rule, being more sandy and stony and in places largely covered with boulder drift, and much less productive than that of the section just described, while its elevation above the sea level, ranging from 1,000 to 1,800 feet, is such that early frosts are frequent, and the ripening of the less hardy grains rendered somewhat uncertain.

Throughout the townships of Wotton, Ste. Camille and St. George de Windsor, the decay of the Cambro-Silurian slates has produced large areas of excellent land, much of which is still uncleared. **Good land.**

The country occupied by the metamorphic rocks has generally a rugged and broken surface, and as already stated these rocks do not, as a rule, afford a very fertile soil. The same remarks also apply to that portion where the volcanic belt of the Lower Cambrian is found, though the overlying basins of Cambrian slates frequently present a good soil, well adapted for agricultural purposes.

ECONOMIC MINERALS.

Gold.—By reference to the reports of the Geological Survey, 1847-48, p. 76, it will be seen that the first discovery of gold in the province of Quebec, is supposed to have been made in the Chaudière valley, by a daughter of one of the *censitaires* of Mr. C. DeLery, on a small stream called the Touffe des Pins, a branch of the Chaudière River, and shortly after, acting upon this discovery, loose pieces were picked up by Mr. DeLery himself in this stream. This fact was communicated to the public in Silliman's Journal, vol. 28, p. 112, 1835, by Capt. F. H. Baddeley, R.E. Subsequent examination of this locality resulted in the finding of small lumps and grains which were simply collected by hand, and the value of the gold so obtained from the time of the first discovery to the end of Oct., 1847, was estimated at about $300. The source of the gold was not at that time definitely known, though it was supposed to be from some of the numerous quartz veins seen in that neighborhood. In this report also, attention was called to the occurrence of gold in a vein in the vicinity of Sherbrooke, found in making an assay for copper; the amount, however, was held to be of no economic importance, being only about ($1.00) one dollar per ton of rock, except in its bearing upon the possibly richer auriferous character of the quartz veins in this section of the country. **Early history of the Chaudière gold-field.** **Gold near Sherbrooke.**

In the Geological Survey Report for 1849-50, attention was also directed to the further discovery of gold at several points along the valley of the Chaudière, as far as the Metgermette, about fifteen miles south-east and above the mouth of the Famine River. Other localities in which it was at that time noted, beside the Touffe des Pins, were the Ruisseau Lessard, the Ruisseau du Lac Moulin, the Bras, about **The Chaudière and its tributaries.**

one mile below the Great Fall, and the Guillaume or Calway, just below the fall in that stream, the quantity found, however, being comparatively insignificant.

Extent of the gold-fields known in 1850-1851.

In the Report for 1850-51, it was further stated that the auriferous district was known to embrace an area of 3,000 to 4,000 square miles, and to occupy nearly the whole of the province lying to the south-east of the prolongation of the Green Mountain range into Canada. The lowest point in the valley of the Chaudière, where gold was found in the drift, was a small stream on the left side of the river, not far within the south-east boundary of the Seigniory of Ste. Marie. Thence, ascending the river, it was found on four tributaries in the Seigniory of St. Joseph, one of which joined the stream from the left, about one-fourth of a mile below the parish church. Of the other three on the right, the lowest was about two miles below the church, the next, two miles above it, and the third was the Rivière des Plantes, near the south-east boundary of the seigniory. In Vaudreuil, Beauce, traces of gold were found on the Guillaume and the Bras, on the latter of which and its tributaries, it was traced for a distance of twelve miles. In addition to the other streams already noted, it was found in Aubert de L'Isle on the Famine, for a distance of about ten miles from its mouth, and in the Ruisseau De L'Ardoise, one mile further up the Chaudière, and on the Pozer stream on the opposite side of the river, for about three miles up from its mouth. On the Du Loup, it was found almost continuously from its junction with the Chaudière, almost across the townships of Jersey and Marlow, as well as in nearly all its tributaries for several miles, being apparently more abundant or more generally distributed in this section of the country than further down the river, where first discovered. On the main Chaudière, above the Du Loup, it was traced for a distance of sixteen miles to the south-west boundary of Dorset.

Gold of Dudswell and vicinity.

Farther to the south, it was also found on the St. Francis at Dudswell, at Westbury, and near the joint corner of the townships of Stoke, Eaton, Westbury and Ascot, as also near the town of Sherbrooke. In all these localities, the gold obtained was from the drift only.

Geology of Canada 1863.

Attention having now been directed to the auriferous character of the localities mentioned, further examinations were made by the Geological Survey, but more largely by private individuals and companies. The results of these explorations and trials appeared in the several reports of the Survey, and were summarized in the Geology of Canada, 1863, pp. 518 and 520. The source of the gold was at that time supposed to be the crystalline schists of the Notre Dame range; the materials from their disintregration being spread over a considerable area to the south. Native gold with galena was also reported from

Supposed source of the gold.

quartz veins at the Rapids of the Chaudière, near St. Francis, as also in a vein with copper glance and bitter spar in Leeds, Lot 15, Range XIV. (Geology of Canada, 1863, p. 730 and 739.)

Gold on the Magog River.

Mention was also made of the finding of gold in the drift along the Magog River, in Lots 2, 3 and 6, Range XIII, Ascot. The results of washings on the Chaudière in 1851–52, made under very disadvantageous circumstances, and with ordinary appliances, showed a very fair margin of profit, and the conclusions then arrived at were, that the amount of gold obtainable by washing on the river was such as, with skilled labor, to warrant the outlay of capital in its extraction, and that by the employment of the hydraulic process, largely adopted in Australia and in California to work gravels which contain a very small proportion of gold, very profitable returns should be made. Unfortunately, the only attempts of any importance made in this direction on the Du Loup and Chaudière, although no official returns are at hand, do not appear to have been as successful as was anticipated, though it does not of necessity follow that a failure in a first attempt should condemn the system for the entire district.

Profitable returns warranted by the explorations of 1851.

Report of the Select Committee of the Quebec Government, 1865.

The labors of the Select Committee, appointed by the Quebec Government, in 1865, to obtain definite information as to the extent and resources of the Canadian gold fields, brought to light a large amount of information, much of which is of great importance, as relating to the value of this section as a gold producing district, and the testimony of all the witnesses seemed to point to a conviction on their part, that under more favorable conditions than apparently then existed, owing in part to difficulties in the matter of titles, royalties, etc., very profitable returns could be realized.

Reliable returns not available.

The returns of the amount of gold obtained since that date would also, if available, aid us in forming more definite conclusions as to the gold producing capabilities of the district, though it should be borne in mind that all, or nearly all, the mining yet carried on in the province, in so far, at least, as can be ascertained, has been done in a comparatively rude way, and without much attention to modern improved methods. The results obtained, therefore, even if unsatisfactory, should not be regarded as conclusive, especially when contrasted with the very different results which should follow a judicious investment of capital and proper scientific modes of working.

Examinations by Messrs. Hunt and Michel.

The results of the examination of the Chaudière district by Mr. A. Michel, with more particular reference to the possibly auriferous character of the quartz veins, and the assays of a number of specimens of quartz, from different localities, by Dr. T. S. Hunt, are given in the Geol. Survey Report 1863-1866. These results, indicating the existence of veins carrying gold in paying quantity, were very favor-

able, the assays, in some cases, showing a percentage quite as high as the average obtained for quartz veins in California, Australia, or Nova Scotia. As might naturally be expected, several samples gave no gold, but this is a feature common to all countries, and only shows that all parts of the same vein are not equally auriferous. The most satisfactory method of testing these leads would evidently be to subject large quantities to trial in a stamp mill, and till this is done, their actual value, must, to some extent at least, remain in doubt. That some of the veins contain gold in paying quantity, we already know. In this connection, we will here quote the results obtained by Dr. Hunt and Mr. Michel. The assays of Dr. Hunt embraced some thirty-one samples, obtained from twelve localities, each in portions of 100 grammes. The following results were obtained, the value of the gold being estimated at $20 per oz. Troy of 480 grains:—

Assays of quartz by Dr. Hunt.

1. Vaudreuil.—L. 83, R. I., N.E. Two assays. No trace of gold.
2. " L. 21, Con. St. Charles. Five assays. Of these, four gave an average of 6 dwts. 13 grs.=$6.76, the fifth of which contained a large scale of gold at the rate of 4 ozs. 18 dwts.=$101.29. The average being for the five samples, $25.66.
3. " L. 62, R. I., N.E. Two assays. No trace of gold.
4. " L. 19, Con. St. Charles. Six assays. Mean of four gave 4 dwts. 21 grs.=$5.03. Two others, counting scale of gold, 3 ozs. 2 dwts.=$64.07. Average of six assays, $24.71.
5. " L. 39, R. I, N.E. Two assays. No trace of gold.
6. " L. 20. Con. DeLery. Two assays. Mean, 14 dwts. 16 grs.= $15.15.
7. " L. 53, R. I., N.E. Two assays. No trace.
8. " L. 59, R. I, N.E. Two assays. "
9. Aubert De Lisle.—L. 9, R I. Two assays. "
10. Aubert Gallion.—L. 30, R. I. Two assays. "
11. Linière.—L. 76, R. I. Two assays. "
12. " L. 2, R. I. Two assays. Mean, 6 dwts. 13 grs.=$6.76, per ton of 2,240 lbs.

Remarks of Dr. Hunt on the auriferous character of the quartz veins of the Chaudière district.

Dr. Hunt says:—"If we compare these assays with those mentioned by Mr. Michel, we shall see full proof of the irregularity with which gold is distributed in the gangue. The quartz from several of these veins was assayed by Dr. A. A. Hayes, of Boston, whose results, which are worthy of the highest confidence, are given by Mr. Michel, together with other assays by persons unknown to me, but probably reliable. The quartz of No. 1 had given in Boston $37.00, and in another assay on the spot $106.00 to the ton. The mechanical assay by Mr. Michel also yielded a portion of gold, while two assays by me gave no trace of the precious metal. Again, in the case of No. 2, Dr. Hayes obtained $77.56, and Mr. Coban $54, while an assay of the same vein yielded me $101.29, and from others a mean of $6.76. No. 3, in like manner,

is said to have furnished gold, though none was found in the specimen just assayed. Nos. 4 and 6 yielded gold to Dr. Hayes and myself, while yet No. 8, which gave traces of gold to Mr. Michel's mechanical assay, and of No. 11, which is said to have yielded gold to a New York assayer, the specimen furnished me yielded no trace."

Assays of specimens from the Marlow silver mine made by Prof. J. T. Donald, of Montreal, show that the quartz leads of that locality, in addition to the silver and lead, contained gold, in most cases only a trace, but in one instance, half an ounce to the ton. This amount even, if constant, would pay a large proportion of the expense of working this part of the property. **Assays by Prof. J. T. Donald of Montreal.**

There is one feature of the Chaudière district, to which attention has not, till within the last few years, been directed, viz., the existence of old river channels, not only in connection with the main stream, but along its several tributaries. The importance of this feature has been pointed out by Dr. Selwyn. (See Geological Survey Report for 1870-71, pp. 275-76.) The value of these old channels was established on the Gilbert stream, where a large amount of gold was obtained some years ago under most unfavorable conditions, several pieces being found which were stated to be worth over $1,000 each. Upon the cessation of work on this stream, the St. Onge Brothers began operations on a small stream above the Famine, known as Slate Creek, and again established the existence in this direction, of an old river bed, which was reached at a depth of 165 feet, nearly 100 feet below the present bed of the stream. In the bottom of this old channel a layer of gravel, now being worked by the St. Onge Mining Co., having a thickness of four to six feet, was found. Great difficulty was experienced in sinking the shafts, owing to the quantity of quicksand encountered, and repeated trials were made, extending over a period of several years before the bed-rock was reached. From the table of the materials passed through in this shaft, which was given on page 49 J, it is evident that the gold underlies the clay at the top and is entirely confined to the lower sands and gravels above the bed-rock. **Importance of the old river channels as a source of gold.** **Old valley of Slate Creek.**

Doubtless, by the judicious expenditure of money in exploration, many other old channels will be found, indications of such being visible in the Famine River, the Pozer stream, and at other points. That much of the gold is derived from veins *in situ* is pretty conclusively established from the assays already quoted, as well as from its coarse character and the size of many of the nuggets obtained, clearly indicating that their source is not far removed. Further evidence is afforded by the presence of pieces of gold-bearing quartz, in which but slight indications of abrasion are apparent, both the gold **True source of the alluvial gold of the Chaudière district.**

and quartz being but little worn and proving conclusively that they were derived from the veins in the immediate vicinity.

Ditton gold-field.

All the reports bearing upon the gold of Quebec refer only to the Chaudière valley. Other areas are known which promise quite as good returns to capital well applied; among them may be mentioned the upper waters of the Salmon River, more particularly in the township of Ditton. That attention has not been directed to this locality is in large measure due to the fact that what is regarded as the most promising field for work is entirely in private hands, and no royalty being in consequence paid to the Government, no official returns are available as to the amount of the precious metal obtained. Alluvial gold has, however, been found there, and worked for many years. The place where operations have been more particularly carried on is on the Little Ditton stream, on Lots 23 and 24, R. IX., Ditton. Nuggets ranging in value from $50 to $150 are reported as having been found. The rocks are black, wrinkled, and sometimes pyritous slates and grey sandstones, in character similar to much of those on the upper part of the Chaudière, and also to those of the gold series of Nova Scotia. Veins of all sizes, up to several feet, traverse the slates, generally with the bedding, though occasionally transverse to it. No attempt has yet been made, in so far as could be ascertained, to test the value of these veins, though that some of those on the Little Ditton are auriferous is proved by the finding of ragged gold in quartz in close proximity, and below them in the bed of the river.

Lack of official returns.

Auriferous veins of the Ditton River.

Unsatisfactory methods of working.

Though a considerable amount of work has been done on this stream and a large quantity of gold obtained, no scientific mining has been attempted. The ground being generally low, the facilities for getting rid of tailings are very poor, and in many of the trials the bed-rock does not appear to be reached. From the specimens already obtained, and the generally favorable results of the work already done under unfavorable circumstances and with ordinary appliances, it is evident that much rich ground must exist in this vicinity.

Course of the Ditton quartz veins.

The veins seen on the Little Ditton apparently extend south-west through Emberton, the belt evidently being the continuation of that in Maine near the boundary between the Hall and Indian streams. To the north-east they can also be traced for several miles, and the anticlinal seen in this locality is recognized in the upper waters of the Du Loup, as already pointed out in the remarks on the Cambrian.

As regards the true source of the gold, while it may be generally stated to be found in nearly every brook or stream in the South-Eastern Townships, more especially east of the Stoke Mountain range and the extension to Lake Memphremagog, the precious metal over the greater part of this area is in an exceedingly fine state of division, as though

derived from some distance. This is characteristic of the country which is, for the most part, occupied by Cambro-Silurian sediments; whereas, when we approach the belt which is supposed to be of Cambrian age, the gold becomes coarser and the quartz-veins are probably auriferous. This feature has also been pointed out in earlier reports, though the greater portion of the strata were then held to be of Upper Silurian age. The resemblance of these Lower Cambrian rocks to those of the gold series of Nova Scotia, which have long been regarded as of the age of the Lower Cambrian, was pointed out some years ago by the late Sir Wm. Logan (see Geology of Canada, 1863, p. 745), and has been already referred to in this report. The probability that these rocks are of the same age as those of the Nova Scotia area is manifestly very important in connection with the question of the occurrence of gold in paying quantities, and is a point that should not be lost sight of in future operations. In that province, within the last few years, the finding of new and wonderfully rich deposits is frequently reported, and it can safely be said that the prospects of highly profitable mining never looked so bright as at the present time. The prospecting in eastern Quebec has as yet been largely confined to one locality, in which the results have often been satisfactory, while a large area of similar rocks remains comparatively untouched, and the true value of the gold-fields of the Townships cannot be said to be yet ascertained.

Gold probably derived from the Cambrian slates.

Comparison with the gold areas of Nova Scotia.

The erection of one or more improved stamp mills, by which the quartz-veins of the Chaudière district and those of the township of Ditton might be practically tested, would do much to settle this question. Only one attempt in this direction was made, some years ago, but, either through defects in the mill itself or through bad management in the working, the returns from it could not be depended upon, and persons interested in the quartz industry soon lost confidence in its efficiency to thoroughly test the question at issue.

Best methods of testing value of quartz veins.

The official yearly returns of the amount of gold obtained from the Chaudière district will be found in the report by Mr. E. Coste, M.E.

Silver and Argentiferous Galena.—In Geology of Canada, 1863, p. 517, the presence of silver in the copper ores of Acton, Ascot and Upton was pointed out; the quantity, however, was insufficient to render it of economic value. The assay of a portion of a vein from the rapids of the Chaudière, at St. Francis, Beauce, which carried argentiferous galena, blende, mispickel, pyrite and native gold, gave 69 per cent. of lead and 32 ounces of silver to the ton of 2,240 lbs., while a second sample gave 256 ounces of silver to the ton, with traces of gold and silver in the other ingredients of the vein.

Silver from the rapids of the Chaudière near St. Francis, Beauce.

Within the last half-a-dozen years, several veins of argentiferous

Silver mine of Risborough and Marlow.

galena have been discovered, more especially near the boundary of the townships of Risborough and Marlow; they have been opened to some extent and favorable prospects were found. The localities where work was principally done are on lots 1, 2 and 3, ranges XIV., XV. and XVI., Risborough, and lot 1, range VII., Marlow. From the examination of this property, in September, 1885, the following description was obtained, although mining operations, which had been going on under the management of Mr. J. Fraser Torrance, M.E., had ceased in the spring of that year.

Description of the property.

At the first or more northerly shaft, the rock is a hard, greyish sandstone, with interstratified beds of black and grey slates, finely wrinkled and in places containing cubes of iron-pyrites. It dips generally south-easterly $< 70°$ to $75°$, as nearly as could be ascertained. The vein, which is styled the "main vein," has a width of ten to twelve inches, composed of quartz, carrying galena, copper and iron-pyrites, and some blende, in some places heavily charged, in others comparatively barren, probably from a half to a third of the vein carries ore in fair quantity. This shaft was about thirty feet deep, and the vein is of uniform width for that distance. The rock in contact is slightly charged with iron-pyrites. Twenty feet west of this shaft, another vein of about ten inches, called the "north vein," carries ore of a peculiar quality. The gangue is a rusty white quartz, with brownish, grey slates on the north wall, and a dyke of very hard brownish dioritic rock, spotted with greenish gray, separates it from that in the shaft just described. The ore, where exposed at the surface, is confined to the north side, but as only three or four shots have been fired, the opening is small.

Several veins.

In the second or small shaft, sunk about thirty-five feet south of that seen in the north shaft, the lode goes down vertically, with a width of about one foot. It is apparently not as rich as the main vein, but carries galena, blende and pyrites irregularly disseminated, the former, so far as observed, in comparatively small quantity. This vein cuts across the bedding at a small angle, and is intersected by another vein of irregular size, ranging from a few inches to nearly two feet in width. The diorite does not show in this shaft. This latter vein has also been opened 130 feet east, where it crops out in the spur of a knoll, and has a course of about N. 68° E. The shaft is eighteen feet deep.

Nearly a mile south-west, another opening has been made in slates and sandstones of similar character, which dip S. 15° E. $< 70°$, on a vein of rusty white quartz, from sixteen to eighteen inches wide, styled the "Armstrong vein," which cuts across the bedding and carries minerals similar to those already described. The trench being

full of water, the proportion of ore could not be definitely ascertained, but the mineral appears to be disseminated in bunches, large portions of the vein being barren, others comparatively rich. A short distance to the south-west of this, two other veins were noted, of which the largest (the "Senator vein") has a width of eighteen to twenty inches, the other of about three inches. In character of gangue and contained mineral, this resembled closely the last. The containing rocks are hard sandstones and wrinkled slates, like those of the Ditton gold-field.

Rocks similar to those of the Ditton gold-field.

The vein seen in shaft No. 2 was intersected by a cross-cut put in 1,400 feet south-westerly from that point.

On lot 1, range VII., Marlow, veins, ten to twelve inches thick, were seen, cutting slates and sandstones similar to those just noted, carrying in places a large quantity of blende and pyrites, with some galena. The rocks here dip S. 10° E. < 80°. The principal vein dips S. 40° E. < 45°, but smaller veins of an inch or more run with the bedding planes.

Assays of the ore from these several veins show the presence of a fair proportion of silver. These have been kindly furnished me by Mr. F. Torrance, and are as follows:—One specimen from the "north vein," assayed by Rev. E. Pagé, of Laval University, gave 430 ounces of silver per ton of 2000 lbs. One from the outcrop of the "Senator" gave 260 ounces per ton, and one from the "main vein," assayed by Prof. Richards, of the School of Technology, Boston, a little over 29 ounces per ton. The assays by Prof. Richards from a quantity of the ore taken from the Armstrong and Senator veins, gave good returns. Assays by Prof. J. T. Donald, of Montreal, gave for the "Armstrong vein," half an ounce of gold per ton, with traces only of the precious metal from the other leads. Assays made by Mr. Hoffmann, in the laboratory of the Geol. Survey, from different veins, and ordinary samples gave 43.663 ounces of silver to the ton, with traces of gold. Galena is also reported by Mr. Gordon, of Sherbrooke, in what may be the extension of this belt south-westward, in the township of Spalding, about three or four miles north of the International railway, and the same distance west of the boundary, though no particulars are to hand concerning the exact location. Traces of galena were also observed at several places in the quartz veins of Ditton and Emberton, but no attention has as yet been paid to these.

Assays of galena from the several veins.

Copper Ore.—The distribution and mode of occurrence of this mineral, have been so exhaustively discussed in former reports (see Geology of Canada, 1863, pp. 709–737, and Geol. Survey Report 1863-66, pp. 29–45, and in the appendix to that volume), that but little need be said on the subject. Of the numerous mines and localities there described, the greater part have been closed for some years, owing, to some extent,

Distribution of the copper ore given in Geol. Sur. Rep. 1863-66.

to the low price of copper, and the low grade of the ore obtained. Those worked at present are confined to the township of Ascot, in the vicinity of Capelton, where mining is still carried on by two companies, the Orford Copper and Sulphur Company, and J. H. Nichols & Co. The ores are shipped in the raw state to New York, and there treated for the manufacture of sulphuric acid, after which, the residue is worked for copper. The operations of the former company are confined to one shaft, the "Crown Mine," over 1300 feet in depth, with levels driven in the vein, which has a thickness ranging from one to over forty feet, for a hundred yards or more. The copper-bearing lode is affected by faults which have, however, not as yet had any serious effect on the value of the property, being generally of small extent. The amount of copper in the ore ranges from three to five per cent. On the property of the second company two shafts are sunk, the Albert and the Betsey. In the former, the vein was reported to have a width of fifteen feet, but as in the Crown mine, this varies. In the Betsey, a thickness of four feet was reported. The total output from this mine in 1885, was 25,000 tons, and from the Crown Mine 16,000 tons. The quality of the ore is apparently the same at both places.

The Capelton mines.

Attempts were made some years ago to reduce the ore on the spot, and extensive smelting works were erected in connection with the old Capel mines, and on the Eustis property at the Crown Mine. The experiment, however, was not successful, owing to the rapid decline in the value of copper, and these expensive works are now rapidly falling into ruins. It seems pretty clearly established that in the case of the low grade ores, rich in sulphur, such as are found in this section, the only profitable method of handling them, is that now adopted, viz., by the utilization primarily of the sulphur. Details of production to date can be found in Mr. Coste's report, Part S.

Iron ore of Sherbrooke, Smith's Mine.

Iron Ore.—Deposits of magnetite of considerable extent are known to exist at several points, principally in what is regarded as the lowest series of rocks. Of these, apparently one of the most important is seen in the immediate vicinity of Sherbrooke, on Lot 21, Range VI., Ascot, on property owned by Mr. Stephen Smith. The vein, which is from ten to fourteen feet wide, occurs in hard chloritic and felspathic schists, associated with quartz and jasper. The ore, of which about 500 tons have been extracted, is slightly calcareous and of excellent quality. The locality was referred to in the Geol. Survey Report for 1847–48, p. 87, under the head of Jasper, and the presence of the iron was noted. Assays of the ore, recently made by Mr. Hoffmann, gave 54.074 per cent. of metallic iron.

Ascot, Clark's Mine.

A probably larger deposit is found on Lot 8, Range IX., Ascot, on the property of Mr. E. Clark, near the summit of a ridge, having an

elevation of about 1,000 feet above the St. Francis River, at Sherbrooke. The ore is mostly a slaty magnetite, with some hæmatite, and the country rock is largely a chloritic schist; the veins are of different sizes, ranging from a few inches up to masses of ten or twelve feet in width, and are irregularly distributed in the schists, in places following the bedding. The assay of this ore, by Mr. Hoffmann, gives only 28.392 per cent. of metallic iron. Another important deposit of magnetite is found on the west side of Nicolet Lake, in serpentine, and already alluded to on page 42 J. The amount of work done is not sufficient to test the value of the property. A shaft, twelve feet deep, has been sunk in a vein six feet thick at the surface, and reported to increase to eleven feet at the bottom, about one hundred tons of excellent looking ore has been extracted, but no assays have yet been made to test its quality.

Nicolet Lake, Reid's Mine.

Chromic Iron is found in connection with the serpentines at several places in the area under consideration. A deposit on the south side of Lake Nicolet, Lot 4, R. II., Ham, was opened some years ago, and about ten tons extracted (See Geol. Can. 1863, p. 749), but the indications were not sufficiently favorable to warrant a continuation of the work. Within the last five years several openings have been made near Belmina, principally by Mr. W. Grey, (L. 24, R. III., Wolfestown), on the crest of the serpentine ridge at this locality. The deposits are apparently of the nature of irregular pockets. From the most important of these about twenty tons were extracted from a shaft fifteen feet deep. The vein was five feet wide at the surface, but decreased to three feet at the bottom of the shaft. Two hundred yards east of this spot a second opening was made, which produced two to three tons in pieces scattered through the serpentine. Other small deposits were also found, and in all about twenty-five tons were obtained. None of these were deemed of sufficient importance to warrant the expenditure of much capital. No sale has yet been made of the ore, a certain percentage of chromic acid being requisite to render it suitable for shipment to the English market.

Old opening on Lake Nicolet.

Chromic iron of Belmina.

Antimony Ore.—This mineral occurs at only one point in the Townships, in sufficient quantity to render it of economic importance, viz., on Lot 28, R. I. (old numbering), South Ham. The deposit was first noted in Geology of Canada, 1863, p. 876, and more fully described by Mr. Willimott, Geol. Survey Rep. 1880-81-82, p. 3 GG. The property has within the last two years changed hands, and is now owned by Dr. James Reid, of Inverness. Exploratory work is now being carried on with a view to thoroughly test the value of the mine by means of an adit driven in from near the bottom of the hill in which the ore veins

South Ham antimony mine.

are situated, and which it is expected will cut the antimony-bearing strata at a lower level than was reached in the shafts, but nothing definite as to the results has yet come to hand.

Asbestus.—Asbestus mining in the province of Quebec may be said to be comparatively a new industry. Beginning in 1878, it has within the last seven years risen to one of the most important enterprises in this portion of the Dominion. At the request of several of the companies interested in this branch of mining, an examination was made of the principal areas where asbestus is found in workable quantities, the results of which, though necessarily imperfect, are here presented as tending to throw some light upon the progress and present condition of this enterprise.

Situation of the principal asbestus mines.

Asbestus mining is carried on at several points along the line of the Quebec Central railway, viz., at Thetford, Black Lake, in the township of Coleraine, and at Belmina, in Wolfestown. Some work has also been done near Coleraine station. Near Danville, at a point four miles from the Grand Trunk railway, a mine of considerable extent has also been operated for several years.

Companies engaged in mining.

The various companies engaged in mining asbestus at Thetford are King Bros., the Boston Asbestus Packing Co., Irving, Johnston & Co., and Ross, Ward & Co., while at Black Lake are situated the mines of the Anglo-Canadian Co., Frechette's, and the Scottish Canadian Co., formerly the Lionais-Martin property. These all lie along or near the line of the Quebec Central railway, which crosses the properties at Thetford, while at Black Lake it is from a quarter to half a mile distant from the workings. At Belmina, which is four miles distant from the railway at Coleraine station, a small force of men, from six to eight only, have been engaged for several years, mostly in exploratory work, on property owned by Mr. John Bell, of London, Eng.

Distribution of the principal serpentine areas.

The various asbestus mines now operated in the Eastern Townships are all situated on portions of the great serpentine or volcanic belt which extends with tolerable directness, though with frequent breaks, north-eastward from the Vermont boundary for some distance beyond the Chaudière River. Large areas of these rocks also occur in the Shickshock Mountain range, in the northern part of the Gaspé Peninsula, in rear of Ste. Anne des Monts, and they re-appear in this direction on the lower part of the Dartmouth River. Indications of asbestus are found at most points throughout the whole formation, though the mineral appears, in so far at least as at present known, to be most abundant in the localities named above, where mining is now carried on; but there is apparently no reason why it should not be found in paying quantity at other points, especially if we suppose that the

presence of the masses and dykes of granulite, already referred to, really favorably affects the presence of asbestus.

The asbestus traverses the serpentine in irregular veins, from mere threads to a thickness of three and even in some cases of over six inches, and the fibre, unless affected by the dislocations of the containing rock, is always at right angles to the sides of the fissure. The veins are, in many cases, somewhat impure from the admixture of grains or small irregular threads of chromic iron, which break the continuity of the fibre, and the mineral has then to be carefully cobbed in order to separate these impurities. Near the surface the veins are also affected to some extent by the infiltration of water, by which the asbestus is discolored, and its value correspondingly reduced. This is especially noticeable in cases where the serpentine is shattered at the surface, either by the action of the weather or from other causes, but this discoloration ceases as the rock becomes solid. As a rule, the asbestus veins increase in value or quality of fibre as lower depths are reached. They are not, however, continuous; the size frequently varies, and like all mineral veins, they are affected by faults or slides, which often cut off completely a valuable working face. In such cases the slicken sided character of the faces of the fault is very marked, and sheets of impure or imperfectly formed asbestus are found lying along them. The veins have often the aspect of true segregation veins, and the containing walls have in many places a different aspect for a distance of half an inch to three inches on either side.

Mode of occurrence of asbestus.

Character of the veins.

Asbestus mining was commenced at Thetford, in 1878, by what is now known as the Boston Asbestus Packing Co. The demand at that time was exceedingly limited, and considerable difficulty was at first experienced in finding a market. The output for that year did not exceed fifty tons; but its value was soon ascertained, and explorations in the serpentine belt at this place resulted in finding the mineral in workable quantity over a considerable area.

Commencement of operations.

The Thetford River here seems to mark the western limit of the serpentine, the rocks on the other side of the stream being altered slates and sandstones. To the east of the railway, which cuts directly across the mining properties, the serpentine forms a knob with an elevation of ninety to one hundred feet above the track. Most of the works are confined as yet to this portion, and consist of open cuts made on the face or on the top of the hill. But little has as yet been done, apparently, to ascertain the value of the part lying between the railway and the river.

Western limit of serpentine at Thetford mines.

The quality of the asbestus in all the four mines at this place may be stated as excellent. The fibre is fine and readily worked, and the veins are, for the most part, especially in the lower cuts, compara-

Quality of the mineral.

Size of veins. tively free from iron or other impurities; they vary from half an inch or even less to four inches in width, though in the quarry of Johnston & Co., a breadth of over six inches was observed. The fibre in these large veins does not, however, appear to be of such good quality, in so far as yet worked, as in those of less size, and veins of one inch and a half to three inches give as good material as can be wished. Numbers of such veins yielding fibre which ranks as extra firsts, are found in all the mines at this place. At times these appear as a perfect network interlacing the surrounding walls of the openings, and can be counted by the dozen.

While all of these properties may be said to be about equally promising, that of the Boston Company may be specially mentioned, both for the amount of its output, which will probably equal that of the three others combined, as well as for the excellent way in which the property has been developed by its experienced manager, Mr. Thos. Sheridan, with a view to successful future operations. This property illustrates also the remarkable increase both in quality and quantity of fibre as the depth of working increases, a feature now clearly established at all the mines, not only in this vicinity, but also at Black Lake, the proportion of seconds to firsts rapidly diminishing in the lower cuts.

The profitable output of asbestus is at present apparently only limited by the demand. The amount extracted since the commencement of operations may be briefly stated thus:—

Output at the Thetford mines.

Boston Asbestus Packing Co., opened 1878.
Output for 1886, say 700 tons.
Total output to end of 1886, say 3,000 tons.

King Bros., opened 1881.
Output for 1886, say 250 tons.
Total output to end of 1886, say 850 tons.

Irving, Johnston & Co., opened 1879.
Output for 1886, say 400 tons.
Total output to end of 1886, say 2,500 tons.

Ross, Ward & Co., one quarry only.
Output, three years, to end of 1886, say 400 tons.

Cost of extraction. The cost of extraction varies in different localities, and depends to some extent upon the amount of barren rock encountered, which, owing to faults, is greater in some cuts than in others. It may, however, be safely put down at \$20.00 to \$25.00 per ton.

Prices of asbestus. The prices at present obtained for asbestus, at points of shipment along the railways, range from \$50.00 to \$55.00 per ton, for second quality, to \$80.00, or even \$100.00 for firsts, a considerable proportion of that taken from the lower cuts realizing the latter figure. The

Markets. markets are Great Britain, Germany, Belgium, United States and Italy.

The majority of the veins worked range from three-fourths of an inch to two and a half inches. The rock is blasted out and carried to the dumps, where it is broken up and carefully cobbed by old men and boys, who grade it according to color as well as purity of the fibre, with due regard to its length. The wages paid for laborers in the quarry range from $1.00 to $1.10 per day, and for boys and cobbers fifty cents. Mode of working. Wages.

The comparison of the cost of extraction with the value of the raw material, shews a very large margin for profit. The works at this place are, however, carried on for the most part during the six months of summer and autumn only, since it has not been found advantageous, in view of the still limited market, to undergo the inconvenience and extra expense of continuing the quarrying during the winter. As the market increases, however, the mode of working will doubtless adjust itself to the demand.

The properties worked at Black Lake station are situated on the west side of a steep ridge of serpentine which rises to an estimated height of about 900 feet above the lake. The Black Lake mines.

The three areas already mentioned are contiguous, and the workings are situated from a fourth of a mile to half-a-mile from the railway. They consist of open cuts as at Thetford, made in the face of the hill, in all of which veins of excellent asbestus are disclosed, ranging in thickness up to four inches. The fibre in most of these is somewhat discolored from the infiltration of water through the shattered serpentine, and as a consequence the greater part of the output has so far graded as seconds and thirds. In most of the openings, solid rock is now reached, and the quality is improving. These mines have not been in operation as long as those of Thetford, but the increase in the output from year to year shews their rapidly growing importance. Shattered character of the serpentine at surface.

Output at the Black Lake mines.

The Anglo-Canadian, formerly Hopper's, mine—		
Output for 1886, say	550	tons.
Total output to end of 1886, say	1,500	"
Frechette's Mine, worked only one year—		
Estimated output for 1886	200	"
Scottish Canadian—		
Estimated output for 1886	250	"
Estimated total to end of 1886	700	"

On the latter property a large amount of heavy exploratory work has been done.

The cost of mining at Black Lake varies but little from the average of that at Thetford, and may be stated at $25.00 per ton. Cost of mining.

There are several other properties in the vicinity of Black Lake, on which the exploratory work done, though not very extensive, shews in-

Contiguous areas at Black Lake.

dications that a profitable output may be expected. These are known as the Reid and Hayden properties, and are situated on lots 27 and 28, R. B., Coleraine. In various open cuts on the sides of the hills, numerous veins are disclosed, ranging up to a width of two and a half inches, with surface indications apparently in no way inferior to those of the adjoining areas now being worked at this place, or even to those at Thetford, not only as regards the size and number of veins, but also as to the quality of the fibre.

Between these lots and Caribou Lake, the serpentine extends in an apparently continuous ridge, and also shows at intervals very good indications. This area has not as yet been explored to any extent, and but little can be said as to its actual value.

About Little Lake St. Francis also, ledges of serpentine are exposed, which deserve careful examination.

Coleraine station and vicinity.

In the vicinity of Coleraine station, serpentine is seen; but the principal ridge, which extends southward from Black Lake, keeps to the west about one mile and a half, where it forms a conspicuous hill feature. This has been but little prospected, but during the past year an opening was made on its south-eastern extremity, which disclosed the presence of a number of veins of asbestus, one of which was nearly four inches wide near the surface. Sufficient work was not done, however, to determine their persistence and value.

An interesting feature in connection with this opening is the presence of mica in considerable quantity in direct contact with the asbestus, a feature not observed elsewhere.

Wolfestown.

The asbestus mines of Wolfestown are situated at Belmina on the north-eastern extremity of a serpentine ridge, which extends, with several inter ruptions, south-westerly from the road leading from Coleraine station, to Wolfestown P.O., to the vicinity of Lake Nicolet. These mines are owned by Mr. John Bell, of London, Eng., and though a considerable amount of money has been expended, it has been largely on exploratory work. The surface indications, while not equal to those

Belmina Mine.

of the Black Lake area, yet shew at several points numbers of veins, some of which reach a width of one inch and a half and even two inches. A very fair showing of workable veins, to some extent affected by faults, has been exposed in the upper part of a deep cut, and an attempt is now being made to intersect these at a lower level. If the rate of increase noted at the places already described occurs here, there should be good paying ground when the lower level is driven past the capping of barren rock, provided the veins already disclosed are not cut off by the faults above mentioned. Only a small force of men is employed, and it would be very difficult, from the limited amount of work done, to express any decided opinion as to the value of this property. Dykes

and large masses of white granulite, similar to those of Thetford and Black Lake, are found in the cuttings and in the adjoining hills.

The total quantity of asbestus taken from this area, which is known as the Belmina Mine, is about twenty-five tons.

In addition to the properties described above, the only other point known to us at which asbestus has been worked successfully, is on Lot 9, R. III., Shipton, about four miles from Danville. The outcrop of the serpentine here is quite limited, with steep sides all round. It contains a quantity of veins, mostly of small size, though the quality of the fibre is good. Faults have apparently affected the value of this property considerably, some very good veins, with a width of two inches, having been completely cut off at a depth of fifty feet from the surface. The output, however, has been considerable; that for the year ending 28th Aug., 1886, being 455 tons, though from various causes it is now much less than formerly, the mine not being worked at present to its full capacity. Jeffrey's Mine, near Danville. Output.

It will be seen from the facts here presented that the asbestus interests of the province are exceedingly important; and judging from the rate of increase for the last six years, it will soon assume very large proportions. The demand is annually increasing as new uses for the material are being found, and from the prospects presented, not only in the mines already opened, but in those areas contiguous, and which appear equally rich, the supply is practically limitless.

Soapstone or talc.—The character and distribution of Soapstone are given, so far as then known, in Geol. of Can., 1863, pp. 469 and 496. While deposits occur at many points in the serpentines and talcose slates of the Townships, the most important in the area now under consideration are found in the townships of Hatley, Ham, and Wolfestown. At the first locality areas of steatite of considerable extent, much of which is of excellent quality, are seen on Lots 19, 20 and 21, R. V., along or near the north-west shore of Lake Massawippi. These have apparently not been utilized, except to a very limited extent for local purposes. In Ham, deposits are found on Lots 43 and 44, new numbering, R. I., near the south extremity of Lake Nicolet, on property owned by Mr. E. Clark, of Sherbrooke, as well as on Lots 49 and 50, R. I., owned by Dr. J. Reid. Mr. Clark has opened his property very slightly, and has removed none for shipment. The soapstone of Wolfestown on Lot 19, R. I., owned by Mr. Calvin Carter, is a pure variety in places translucent in thin plates, and occurs as a bed from one to ten feet thick, in black and grey talcose schist. It has been used for the manufacture of slate pencils and tailor's chalk. A considerable quantity has also been ground and bolted, and is then well Hatley. Ham. Wolfestown.

adapted for a filler in the manufacture of paper. When mixed with a small proportion of white lead, it forms a hard cement-like pigment, which is claimed by Mr. Carter to equal in resistance many of the more expensive fire-proof paints. The price of this talc, ground and delivered in bags at the nearest railway station, Coleraine, is $8.00 per ton of 2,000 lbs. Good sized slabs, of fine quality, can be obtained from this locality. It is also excellently adapted for the manufacture of gas burners.

North Stoke.

Mineral Pigments.—The only deposit of this nature which came under our observation, and to which special attention need be directed, is on Lot 12, R. XIII., Stoke, on the property of Royal M. Gansby. Two shades were observed, one yellowish and one reddish-brown; by calcination, the former assumes a pinkish tinge, and the latter a darker color. This pigment has been tested by Mr. L. J. Giroux, of the Canada Atlantic railway, and found to answer well for ordinary purposes; it is about equal to what usually retails for one and a-half to two cents per pound. When mixed with the ground talc of Mr. Carter's mine, it is said to form a very durable coating for outside work. Reference was also made in the Geol. Survey Rep. 1847-48, to the occurrence of stone paint on Lot 13, R. IX., Stanstead, as the result of the decomposition of bluish-grey and talcose slates, the colors being ochre, yellow, and greyish-white. The material, mixed with oil, has been used locally for house painting.

Stanstead.

Dudswell marble quarry.

Marble.—A large deposit of crystalline limestone, forming a marble of very excellent quality, is found in the township of Dudswell, at Lime Ridge and vicinity. Its occurrence on Lot 22, R. VII., was pointed out by the late Sir Wm. Logan. (Geol. Surv. Rep. 1847-48, and subsequently in Geology of Canada, 1863, pp. 627, 827.) Within the last two years, attention has been again directed to this locality, and a company has been formed in Sherbrooke to thoroughly test the value of the property. The marble is of several colors, takes a beautiful polish, and presents a very handsome appearance, especially a kind known locally as "black and gold," the yellow being due to the presence of veins of dolomite. There are also various shades of grey. In places the ledge is composed almost entirely of fossil corals, the polished slabs of which present a very peculiar and pretty mottled aspect. The company has set up a channelling machine, and the upper and somewhat shattered layer has been removed to a depth of about four feet from the surface, in order to test the soundness of the beds beneath, the result being apparently satisfactory. They have also erected a sawing apparatus for the purpose of cutting the blocks into slabs. Sufficient work had not been done at the time of our visit to thoroughly test the quarry, but the prospects seem favorable.

Limestone.—A portion of this deposit has been worked for some years by the Dudswell Lime and Marble Co., whose quarry is situated at Lime Ridge. Six draw-kilns are now in operation with a capacity of 1,000 bushels each. The quarry, which is at one extremity of a ridge of highly crystalline limestone of very fine quality, has now a working face of about 100 feet by 50. The facilities for working and shipment are excellent, and the output is very large. A constantly increasing demand is met with, the market embracing the greater part of eastern and south-eastern Quebec and the adjoining states. Complete returns to date will be found in the report by Mr. E. Coste, M.E. **Lime Ridge.**

Flagging Stone, of very fine quality, is also found near by in Lot 15, R. V., Dudswell, also first pointed out in the Geol. Survey Report for 1847-48, p. 83. Four quarries are now in operation, owned principally by Bentley & Sons and Henry Sunbury. The rock which dips south-easterly at an angle of twenty to thirty degrees, is a bluish dark limestone, in regular beds, ranging in thickness from one to eight inches, with dark shaly partings. Stones of almost any required size can be taken out. The quarries have been opened but a short time, but the market is rapidly increasing. At present almost the entire output is sent to Montreal, where it is largely employed. **Dudswell quarries.**

Flagging is also found in connection with the Cambro-Silurian slates near and in rear of Brompton Falls, on the road west from Sherbrooke to Melbourne, and on the property of Duncan Haggart. The rocks here dip north-westerly, are nearly vertical, and present a good face for working. Large slabs have been taken out and used for flagging in Sherbrooke and locality, and give good satisfaction. The cleavage is not sufficiently regular for roofing slates. **Near Brompton Falls.**

The limestone of Lake Memphremagog, in the vicinity of Oliver Corners, also in places afford good quarries of flagging, which have been used locally to some extent, and appear to be of excellent quality. **Oliver Corners.**

Granite.—The granites of this area have already been fully described in earlier reports as affording excellent building stone. They cleave readily and dress easily. They have been largely used in the construction of bridges on the several lines of railway, as also in Sherbrooke, where they are seen in the new Eastern Townships Bank and the new Post Office and Custom House. They are also used locally and are in considerable demand for monuments.

The principal quarries are in the township of Stanstead, near the extremity of Magoon's Point, on Lake Memphremagog, and near Stanstead Junction or Beebe Plain. Outcrops of granite also occur between Barnston and Coaticook, and at other points, which have already been mentioned in previous pages. **Principal granite quarries.**

Serpentine.—The distribution of this rock has already been given. Blocks and slabs have been taken out and polished, at intervals, for many years ; some are admirably adapted for interior decorative purposes, and are very beautiful. The stone, however, is not suited for exterior work as it weathers rapidly and loses its polish. Difficulty is experienced in getting out large and perfect blocks owing to the presence of numerous small flaws and the jointed character of the rock which renders it difficult to split in any given direction, but for the manufacture of small articles it furnishes a handsome and easily worked material.

New Rockland Slate Co.

Slate.—Only two slate quarries are at present in operation, that of the New Rockland Slate Co., in the township of Melbourne, and the Danville School Slate Quarry, which has been closed for some years, but lately re-opened by a new company. The details of the former, which is now being worked on a very extensive scale, will be found in Mr. Coste's report. To facilitate transport, the Company have, during the past year, built a line of narrow gauge railway from the Grand Trunk to their quarry, a distance of about four miles.

Danville Slate Co.

At the Danville quarry the work so far has been largely of a preliminary nature. The old excavation has been cleared out, new buildings and dressing sheds erected, and improved machinery put in. The character of the slate is excellent, especially for the manufacture of school slates, though the Company purpose extending their business by manufacturing other lines, as mantles, billiard-table-tops, &c. Prospecting has also been going on in a band of red slates in the vicinity, the results of which have not yet been ascertained.

Whetstones.—Rocks suited for this purpose have long been known to exist, and are described as occurring in the altered slate series of Memphemagog Lake, as well as in similar rocks in North Hatley, (See Geol. of Can., 1863, p. 809), and in the township of Stanstead, but little has of late been done towards the development of this industry, and no returns as to production are to hand.

Brick-clay, while found at many points, is used for the manufacture of bricks, in so far as at present known, at only three places, viz., Sherbrooke, Lennoxville, and Ascot station, the largest output being at the first locality. The returns of each will be found in the report of Mr. E. Coste, M.E., Part S.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

TO ACCOMPANY QUARTER-SHEET MAPS 3 S.E. AND 3 S.W.

SURFACE GEOLOGY.

NORTHERN NEW BRUNSWICK AND SOUTH-EASTERN QUEBEC.

BY

R. CHALMERS.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1887.

ALFRED R. C. SELWYN, ESQ., LL.D., F.R.S., ETC.,
Director of the Geological and Natural History Survey.

SIR:—I have the honour to present herewith a detailed report on the surface geology of the district comprised within the two quarter-sheet maps, 3 S.E. and 3 S.W., (northern New Brunswick and south-eastern Quebec), being the result of explorations and surveys made chiefly during the summer of 1885. The two map-sheets referred to, with colouring and notation to illustrate the surface deposits of the region, are now ready and will accompany this report.

My thanks are especially due to W. Mann, C. E., Bathurst, for a plan of the Caraquette Railway; and to H. A. Johnson, Dalhousie, and Miss Andrews, Bathurst, for barometric readings taken at the meteorological stations under their charge.

I have the honour to be,
Sir,
Your obedient servant,
R. CHALMERS.

OTTAWA, May, 1886.

REPORT

TO ACCOMPANY QUARTER-SHEET MAPS 3 S.E. AND 3 S.W.

SURFACE GEOLOGY.

NORTHERN NEW BRUNSWICK AND SOUTH-EASTERN QUEBEC.

In the Annual Report, Geological Survey, 1885 (report GG) a general description of the surface geology of northern New Brunswick is given, with a brief sketch of the geological relations of the deposits, remarks on their agricultural capabilities, etc. The present report is intended to be of a more detailed character, and besides, will embrace a certain part of the province of Quebec, especially the area drained by the Restigouche and other rivers falling into the Baie des Chaleurs. As the glacial phenomena of this region, as well as the distribution of the surface deposits, stratified and unstratified, have been so largely influenced by its more prominent physical features, it is only by viewing the drainage basin of the Baie des Chaleurs as a whole that it is possible to treat the surface geology in a connected and systematic manner. For this reason and also to complete the study of the area included in the quarter-sheet maps, 3 S.E. and 3 S.W., the explorations of the season of 1885, extended beyond the limits of New Brunswick as stated, and the larger part of Bonaventure county was also examined. Moreover, the oscillations of level which the region, embraced in this report, underwent in the Post-Tertiary period as well as its glaciation are obviously so related to similar phenomena on the northern side of the Gaspé peninsula or Notre Dame Mountains that it seemed desirable and necessary, in elucidating them, that a cursory examination, at least, of the lower part of the St. Lawrence valley should be made. Accordingly, a short time was spent in the early part of the summer between Rivière du Loup and Métis, where a number of facts were discovered which, correlated with those of a cognate character observed in the Baie des Chaleurs district, must have an import-

Previous description of region.

Influence of physical features.

Area explored.

Relation of surface geology of northern New Brunswick to that of south-eastern Quebec.

ant bearing on investigations regarding the surface geology of eastern Canada. These facts may here be given in some detail:—

Observations at Rivière du Loup.

At Rivière du Loup, marine terraces were found at elevations of 225 and 345 feet;* in the lower of these, shells of *Saxicava rugosa, Macoma Grœnlandica, Mytilus edulis* and a species of *Leda* or *Yoldia* occur in Leda clay of unknown thickness, overlain by Saxicava sand to a depth of fifteen feet. The ridge on which Cacouna village stands is highly glaciated, the striæ running N.E. and S.W. or parallel to the general course of the St. Lawrence valley. The extensive terrace on which Cacouna station (263 feet high) stands is evidently of marine formation. On the road leading southward from this station, other terraces and old shore lines were observed, the highest being 340 feet. Fine blown sand occurs in the uppermost terrace. Along what must have formed the ancient beaches referred to, great numbers of boulders are strewn, chiefly of granite, gneiss, felsite, etc. Above the 345 feet contour line the surface appears to be more uneven, terraces are absent, and boulders not so numerous.

Cacouna.

St. Arsène.

An extensive marine terrace also occurs at St. Arsène station (277 feet high), in which shells of *Saxicava rugosa* were detected. Another behind it abuts against an old shore line or bank at a height of 340 to 345 feet. These terraces are continuous to Cacouna station, three miles distant.

Trois Pistoles.

Half a mile west of Trois Pistoles station (100 feet high), at a small stream, rocks were seen planed and striated in the direction of N. 2° W. In certain places they were rounded on the southern face and broken off abruptly on the northern. One exposure, however, which takes the *roche moutonné* form, has, in addition to the ice markings mentioned, other striæ on the northern face (which slopes toward the St. Lawrence at an angle of about 30°), the direction being N. 35° E. or S. 35° W., *i.e.*, nearly parallel the St. Lawrence valley. No rounded face (*stoss-seite*) showing in which direction the ice producing these moved, whether up or down the valley, was observed.

A few rods to the east of Trois Pistoles station, another small brook flows into the St. Lawrence, which, in the lower part of its course has cut a deep trench through boulder-clay. Just south of the railway track it falls in a cascade over a ledge which is finely planed and striated,—striæ N. 10° W.—rounded side (*stoss-seite*) to the south, the northern face being abrupt for several feet forming the cascade mentioned. Till rests on the glaciated surface. Numerous boulders of all

* The elevations are above high tide level; those of the Intercolonial Railway stations were obtained from profiles in the office of the Railway Department, Ottawa, through the kindness of Mr. Collingwood Schreiber, Chief Engineer. The bearings given are referred to the true meridian.

sizes up to six feet in diameter occur in the stream bed, the largest being derived from local rocks, but others of granite, gneiss and crystalline schist were noted.

On the road leading from Trois Pistoles station to the back concessions traces of marine submergence were observed up to a height of 345 to 375 feet. Below that level, blocks of granite, gneiss, syenite, felsite, etc. strew the surface in great profusion, all well rounded. Above the limit stated the boulders are, generally speaking, more angular, and fewer gneiss or granitoid ones occur, but a larger number belonging to local rocks. Several of a reddish granite or syenite, *i.e.* containing a large proportion of flesh coloured felspar, were however, met with. Glacial striæ were observed in different places up to the last back settlement, 800 feet high, the *roches moutonnées* and east-and-west ridges presenting, in all cases, the glaciated faces to the south. On a ridge in the third tier, striæ were noted with a course of N. 45° W. to N. 50° W., the ice-worn face (*stoss-seite*) to the south. The difference between the course of these and the striæ nearer the coast, is however, due to local inequalities of the surface. **Rear concessions, Trois Pistoles.**

Along the road from Trois Pistoles to St. Simon, glaciated rocks occur in several places, the rounded faces here also invariably to the south. A short distance to the south of St. Simon station (292 feet high) what appears to be the upper margin of the marine beds was seen along the face of an escarpment, at a height of 345 to 350 feet. A marked distinction was discernible here between the deposits below and above that line, the latter containing angular debris and the surface being without the sweeping rounded contours characteristic of those which have been under the sea. At the level of 375 feet, however, there is here, as at Trois Pistoles, a horizontal mark along the hill sides which may be evidence of an old shore line; but angular boulders of local rocks and the face of the escarpment mentioned are seen for 30 feet below it. **St. Simon.**

Near Bic station (75 feet high) polished rocks occur, but without distinct grooves or striæ. The ice producing these has moved up or down the valley in the direction of S. 48° W. or N. 48° E. **Bic.**

Going southward from Rimouski station (67 feet high) to the rear concessions, terraces at levels of 260, 330 and 367 feet were crossed, the one at 330 feet being the most extensive. The surface of the 367 feet terrace is somewhat hummocky and uneven, but a shore line is traceable here. Below this level, water-worn boulders of granitoid rocks are frequent, while above it, scarcely any, except a few of the red variety were met with, and the debris both large and small is more angular. This is the appearance presented as far as examined, up to a height of 625 feet, nothing like marine action on the surface being ob- **Rimouski.**

servable above the 367 feet contour line. Glaciated rocks and bosses with the ice-worn face (*stoss-seite*) in all cases presented to the south or south-west, were seen in several places, but no fine striæ nor grooves.

St. Flavie.

At St. Flavie station (246 feet high) marine terraces were found extending up to a height of 340 to 345 feet, an old shore line appearing at that level. Immediately below this contour line, great numbers of drifted boulders, all well rounded, were observed, while above it, the surface became uneven and rolling and the boulders of gneiss, syenite and hornblendic rocks scarcer. On going into the back settlements a few of the reddish granitoid rocks were still seen, however, as far as observation extended, up to an elevation of 450 feet or more. A wide terrace occurs at St. Flavie at the 300 feet level, which however, has a slight slope towards the shore. Glaciated rocks with the worn faces to the the south were seen in this vicinity.

St. Octave and Little Métis.

Along the site of the railway at St. Octave station (561 feet high) and Little Métis station (675 feet high) nothing like marine beds was observed, the ground being uneven and hummocky. About 200 to 300 feet below this level, however, the great marine plain on the south side of the St. Lawrence can be seen stretching up and down the valley.

From these facts the following conclusions may legitimately be deduced:

Conclusions respecting glaciation and subsidence of St. Lawrence valley below Quebec.

1. That in the region along the south side of the St. Lawrence, below Rivière du Loup, there has been a subsidence of from 345 to 375 feet with reference to the present sea level in the Post-Tertiary period. Above the 375 feet contour line, no evidence of submergence was seen, and the hummocky nature of the surface, the general absence of foreign boulders, their more angular forms, and the obvious relations of such as are met with to the rocks of the district, support the view that the downward movement has not exceeded the limit stated.

2. That the glacier or glaciers which produced the south-to-north striation moved from the Notre Dame Mountains, or the adjacent watershed, northward, debouching into the St. Lawrence estuary, which must have been at least partially open during the period of their existence.

3. That the north-east and south-west striation has been produced by ice which moved up or down the St. Lawrence valley independently of that referred to in section 2, but whether contemporaneously or earlier or later, or whether the striæ were caused by glaciers alone, or by icebergs, the facts at hand are not sufficient to enable us to decide.

The co-ordination of these phenomena with observations made on the surface geology of the Baie des Chaleurs basin will be brought under review in a subsequent part of this report.

The investigations in the Baie des Chaleurs district have resulted in the discovery of a number of additional facts of importance respecting

the glaciation, the formation of the drift beds, including the origin of the till, of kames, stratified deposits, etc. During the summer (1885) the Restigouche River and its principal affluents, the Quatawamkedgewick, Patapedia, Metapedia and Upsalquitch, were ascended, and a series of observations in barometric hypsometry made, and the general elevation and surface features of the region drained by them ascertained. The valleys of the Scaumenac, Nouvelle, Cascapedia, Bonaventure and other rivers debouching into the Baie des Chaleurs were also examined, and the extent and fertility of the flats or intervales bordering them noted. The forest growth, which is so rapidly being depleted by fires as well as by the lumberman's axe in some parts of the district, the size and relative abundance of the different kinds of trees, the distribution as affected by the geological formations or other causes, were likewise studied as far as time would permit, while attention was also given to the character of the soils and their relative values as derived from each of the series of formations within the area under review.

Investigations in northern New Brunswick and Bonaventure county, Que.

The surface deposits met with in the examination of the district included in the two quarter-sheet maps referred to, may be enumerated as follows in descending order:—

Post-Tertiary Deposits.

Classified list of deposits examined in district.

M 3.

FRESH-WATER.	MARINE.
1. Peat bogs.	1. Estuarine flats.
2. Shell marl.	2. Salt marshes.
3. Lacustrine and fluviatile marshes.	3. Sand dunes.
4. River flats (intervales).	

M 2.

1. River terraces and kames of river valleys.	1. Saxicava sand and Leda clay, and kames of marine origin.
2. Stratified inland gravel, sand and clay, and kames of the higher levels.	(The Saxicava sand and Leda clay often form sea-border terraces.)

M 1.

1. Till or boulder clay, moraines and erratics.

Each of these formations, as it occurs in the district, will be described, and the locality and superficial extent defined on the map.

It is perhaps necessary to state that the section of country included in the maps is settled only along the coast and river estuaries, except near the towns, where occasional back settlements have been established on the second and third tiers of lots. Hence it was impossible to carry out a detailed system of investigation as regards its surface geology in the interior, as only along streams and lumber roads could

Difficulties attending investigations in the interior.

it be penetrated and the character of these observed. From the examination made, however, and the known distribution of the older rocks as mapped by R. W. Ells, of the Geological Survey, it is believed tolerably correct knowledge regarding the interior, as well as along the coasts, has been obtained.

Topographical and Physical Features.

Topographical features, where and by whom described.

The main topographical features of the region under examination have been described in previous reports by different geologists. Sir W. E. Logan and Mr. Richardson each explored portions of the area mapped, lying within the Province of Quebec (Reports of Progress, 1844 and 1857-'58), and the results of their work are given in the *Geology of Canada*, 1863. In Prof. Hind's *Preliminary Report on the Geology of New Brunswick*, 1865, the chief outlines of the topography of the northern counties are given ; but it is to the reports of Mr. Ells (Reports of Progress, 1879-80 and 1880-81-82)), that we are mainly indebted for details regarding its orographical and geological features. The writer has also sketched some of the chief surface characteristics in report GG. (Annual Report, 1885); so that in view of what has already been written respecting the region, it is unnecessary to do more at present than recapitulate the chief points in the descriptions referred to.

The more salient features are the Baie des Chaleurs basin and the estuary of the Restigouche, the former merely a prolongation and expansion of the latter. The estuary mentioned is a shallow basin about twenty-two miles long and from one to three miles wide, lying in an east-and-west direction (magnetic) and surrounded by hills of trap rock which rise 500 to 1,000 feet above sea level.

Restigouche estuary.

Baie des Chaleurs.

The Baie des Chaleurs is a broad sheet of water, the general direction of which is nearly east-and-west, occupying a trough about seventy-five miles long and fifteen to twenty-five miles wide. Its general depth can be seen from an inspection of the map. There is a gradual descent in the contour lines of its bottom eastward, and the depth increases beyond its mouth, for, outside of the Orphan Bank, the lead goes down, according to the charts, 450 feet or more.

Heron Island.

This beautiful expanse of water is without rock or shoal, and has only one solitary isle—Heron Island—lying off the coast of Restigouche county.

Baie des Chaleurs a valley of erosion.

The hydrographical basin of the Baie des Chaleurs is in reality a wide valley of erosion originally formed in the Silurian rocks, which has been partially filled in to a height of 200 to 300 feet above the present sea level by Devonian and Carboniferous sediments. These

again were subjected to extensive denudation. Indeed the existing features are largely the result of erosive agencies continued since the land first rose above the sea, although the mountains and table lands are undoubtedly due to original disturbances and uplifts of the strata. Erosion has, however, been more effective in wearing down the rocks, especially the Lower Carboniferous, on the south side of the Baie des Chaleurs than on the north. From the patches and remnants of these found occupying sinuses and small marginal areas all around the coast, it is evident the whole basin of this sheet of water has been skirted and, perhaps, partially filled in with them, the chief portion of which has since been denuded. Physical features of Baie des Chaleurs district how originating.

In general, the surface of the land may be said to slope upwards from the shores of the Baie des Chaleurs on all sides to an elevation of 1000 feet or more, although within the limits of the maps reaching that height only in the west and north. The 200 feet contour line, marking approximately the upper limit of the marine deposits, gives an idea of the slope near the coast, but the general appearance of the country on either side of the bay is quite different. Along the Restigouche River and in the region west of the Cascapedia River embraced in the maps, the chief portion is a table land, intersected by numerous deep river gorges and ravines, the average elevation of which is about 1,000 feet above the sea. Mountains 1,200 to 1,500 feet high, or more, however, occasionally loom up, and a bold escarpment here faces the estuary of the Restigouche and the Baie des Chaleurs. East of Cascapedia River, the coast district, although not so high as that just referred to, nevertheless maintains an elevated, undulating aspect, exhibiting steep banks and cliffs along the shore in many places, with a surface behind, which, generally speaking, ascends till it merges into the table lands along the watershed of the peninsula. Slopes and elevations. Table lands.

On the New Brunswick side of the bay, to the south and south-east of the Dalhousie or Restigouche hills, the land is comparatively low, with gently rising, uniform, or slightly undulating contours, and is without any eminences, except the Blue Mountains near Jacquet River. This area has evidently undergone great and prolonged denudation, especially near the coast, for, although the rocks are much disturbed, the strata in many places crumpled and upturned vertically, they nevertheless exhibit a comparatively even surface. Character of surface on south side of Baie des Chaleurs.

To the south-east of the Baie des Chaleurs stretches the great Carboniferous plain of New Brunswick. It is a flat district, whose surface within the area mapped does not exceed 200 to 300 feet above sea level, the strata being comparatively undisturbed, and sloping very gently down beneath the waters of the Gulf of St. Lawrence.

A number of important rivers debouch into the Baie des Chaleurs, of Rivers.

which the chief are Restigouche and Nepisiguit in New Brunswick, and Great and Little Cascapedia and Bonaventure in Quebec. In the table land referred to, these have cut deep trenches into the strata, and produced marked features in the landscape. On the lower grounds, however, the river valleys are comparatively shallow, but most of them have been filled to a greater or less depth, especially the estuarine portions, with till and stratified beds, during the glacial period and since.

Elevations along Restigouche River and in the interior.

The elevations of certain points along some of these rivers, and of the adjacent country, as measured by aneroid, may here be stated. They are in all cases above sea level. Along the Restigouche estuary, on both sides, the hills are 500 to 1000 feet; mouth of Metapedia, 20 feet; hills in this vicinity, 600 to 900 feet; mouth of Upsalquitch, 38 feet; general level here about the same as at Metapedia; Red Pine Brook, 170 feet; hills and general level near here, 700 to 900 feet; mouth of Patapedia, 220 feet; general level of country near river valley, 750 to 900 feet, but rising to 1000 or 1200 feet at some distance north of it; confluence of Patapedia and Awaganasees branch, 660 feet; general height of country here beyond valley, 1200 to 1500 feet; mouth of Quatawamkedgewick, 327 feet; hills near river, 600 to 750 feet; mouth of States Brook, on last mentioned river, 567 feet; height of measured hill here, 1300 feet, others rising 1400 to 1500 feet; Restigouche River, at limits of map, below mouth of Gounamitz, 380 feet; hills on both sides, 600 to 700 feet. On the Upsalquitch, mouth of Boland's Brook, is 117 feet, and confluence of north-east and north branches, 180 feet; general level of country in immediate vicinity of latter point, 500 to 600 feet. From these altitudes, it will be seen the country drained by the Restigouche rises towards the sources of the Patapedia and Quatawamkedgewick, and the lowest part is along the main river and the Upsalquitch. The maps show the elevations at all accessible points.

Changes in drainage. Former mouth of Restigouche.

Some changes seem to have taken place in the courses of a few of the larger rivers, one of which may be referred to. During the Post-Tertiary subsidence of the region, the Restigouche had two mouths, and flowed partly out by the gap in the Dalhousie hills, through which the Intercolonial Railway now runs, and partly by the present mouth, Dalhousie Mountain forming an island. The Scaumenac River may have originally determined the existing outlet.

Lakes.

A number of lakes occur in the district, which generally form part of the river systems. They are all, so far as examined, held in by drift dams. The parallel valleys among the trap hills on the south side of the Restigouche estuary are occupied by a number of lakelets, 500 or 600 feet above sea level. The Blue Lakes near the Cascapedia

River are remarkable, especially two of them, for their azure or bluish colour (see report of Mr. Ells, 1880–82). Some of the smaller lakes contain marl, and other lake basins were seen to be wholly filled with peat. Blue lakes near Cascapedia River.

Following is a list of the elevations of the more prominent and accessible mountains within the area under discussion. Those noted on the maps indicate the surface features more definitely than any written description could. The datum line is high tide level of the Baie des Chaleurs. List of mountain heights.

	FEET.
Tracadigash Mountain	1,865
Nouvelle "	1,058
Maria "	1,230
Table land behind Tracadigash Mountain	1,700
Scaumenac Mountain	1,745
Dalhousie "	715
Sugar Loaf " Campbellton, N. B.	950
Squaw Cap " Upsalquitch	2,000
Slate " "	2,000
Port Daniel "	400

Bearing in mind the foregoing facts in relation to topography and elevation, we can now mark their influence on the great erosive forces which swept over the region, producing striæ, distributing boulder-clay, erratics, etc.

GLACIAL STRIÆ.

In the general list of striæ given in report GG (Annual Report Geological Survey, 1885), all those known or observed in the district were recorded, but during the past summer (1885), a number of additional striæ have been discovered, especially on the north side of the Baie des Chaleurs. These, and others not previously noted, are included in the following table. Their courses are all referred to the true meridian. List of striæ.

No.	Localities.	Course of Striæ, &c.	General slope of surface.	Height above the sea.
	Gloucester County, N. B.			
1	At Bass River Mills, along Caraquette Railway.	N. 22° E.	N.	30
2	In Middle River settlement, on road side.......	N. 46° E.	N. E.	250
3	In Dumfries settle't, on central E. and W. road..	N. 56° E.	N. E.	250
4	" in another place on same road.	N. 46° E.	N. E.	200
5	In Robertville, on westernmost N. and S. road ..	N. 86° E.	N. E.	275
6	At Belledune, near P. O., on bank of shore......	S. 54° E.	N.	Sea lev
	Restigouche County, N. B.			
7	In Archibald settlement, near school house.....	N. 12° E.	N.	225
8	" in another place on main road.	N. 21° E.	N.	200
	In both of these places the *stoss-seite* of the rock is to the S. W.			
9	At Benjamin River, on bye-road to second concession lots......	N. 76° E.	N.	
10	In Quatawamkedgewick River valley, 3 miles below mouth of McDougall's Brook. Grooves and striæ................................	S. 38° E.	S. E.	520
	The striæ are parallel to that part of the river valley in which they occur. Till rests on the rock surface, but is now being rapidly worn away by the river (see section under head of till or boulder-clay).			
	Bonaventure County, Quebec.			
11	Near Maguasha Point, *roches moutonnées*........	S. 68° E.	S. E.	200
12	On E. side of Nouvelle Valley, on road to Parker settlement	S. 24° E.	S. E.	700
13	On road to St Louis Mountain settle't. Grooves..	S. 44° E.	S. E.	700
	Ice in two last mentioned localities evidently flowed from table land along gorges into Nouvelle estuary and into W. end of Baie des Chaleurs, coalescing with glacier of Restigouche valley.			
14	At Black Cape, along road in several places, *roches moutonnées*, grooves and striæ	S. 42° E.	S.	250
	These striæ, etc., have been produced by a body of ice which moved down the Cascapedia valley into the Baie des Chaleurs basin.			
15	At Port Daniel Mountain, *roches moutonnées*, and grooves, *stoss-seite*, N.W	S. 46° E.	S. E.	300
16	On second ridge E. of Port Daniel River, along road in several places...........	S. 44° E.	S. E.	225
17	At Point Maquereau, on road leading to light house and along main road in several places.	S. 44° E.	S. E.	300
	The glaciers producing these striæ have evidently debouched into the open bay.			

Till or Boulder Clay, Moraines, etc.

The occurrence of till and erratic blocks on the southern side of the Baie des Chaleurs was referred to in some detail in the report already cited, (Annual Report, 1885. Part GG.) Thick deposits of till were met with in many places near the coast, and in the interior of the country in river valleys. On the Quatawamkedgewick, a tributary of the Restigouche, it was seen near the mouth of McDougall's Brook, in the river's bank, resting on glaciated rocks at a height of 520 feet above sea level, (see list of striæ). The section here is as follows in descending order:— Localities where till was observed.

Quatawamkedgewick.

1. Stratified gravel and sand, overlain by a few inches of loam. Thickness of whole	15 to 20 feet.
2. Till, consisting of gravel, sand and clay with a few boulders, which bakes hard on exposure	3 to 5 feet.
3. Grooved and striated rocks, grooves parallel to direction of valley.	

The river having recently made a detour here, is now wearing away the whole of these beds down to the rock surface, thus exposing the striæ.

At Campbellton, a bed of till occurs in the bank of the Restigouche, overlain by stratified gravel, etc. Campbellton.

Just north of Nash's Creek, on the coast of the Baie des Chaleurs, a bed of till occupies sufficient breadth to enable us to map it. The Intercolonial Railway track passes through it by a cutting fully half a mile long, exhibiting a good section, and showing it to consist of a gray or reddish-gray clay, very tough and compact, and containing numerous angular boulders. The upper portion is more or less oxidized. Nash's Creek.

On the right bank of Jacquet River, near its mouth, a coarse reddish clay and gravel, chiefly derived from the underlying Lower Carboniferous rocks, occurs, which contains glaciated boulders, and is evidently a true till. Jacquet River.

At Tête-à-gauche and Nepisiguit rivers, beds of till met with there, consist principally of the debris of the granite rocks occurring in the vicinity. These river valleys have been partly filled with it during the glacial period, the streams subsequently wearing channels through it. The deposits of till on their banks are, therefore, remnants only of the original mass. Along the Nepisiguit, however, they form a ridge which rises slightly above the general level, similarly to banks observed along the Miramichi and other rivers. Tête-à-gauche and Nepisiguit Rivers.

At Bass River, near the Caraquette railway track, a bed of till is seen with glacial striæ beneath. Here and to the eastward, a sheet of till covers the surface of the Carboniferous rocks, overlaid by a thin deposit Bass River.

of stratified materials. Transported boulders of granite, diorite, felsite, etc., are consequently numerous on the surface. The land is quite flat, clayey, and wet in rainy seasons.

Till at Yacta Point.

A considerable bed of till occurs west of Yacta Point in Scaumenac Bay, composed of tough clay, mixed with boulders derived from local rocks.

At LeBlanc and Little Bonaventure Rivers.

On the coast of the Baie des Chaleurs, between LeBlanc and Little Bonaventure rivers—distance three miles—a thick bank of till is exposed, which is twenty-five to thirty feet high, and half a mile to a mile in width. It is here also composed principally of the debris of the Lower Carboniferous rocks, with a few travelled boulders from the interior of the peninsula. Decomposed rock *in situ* occurs here at different points.

Other localities of till.

Till was also noticed in the following localities:—On the sides of ridges between Point Maquereau and Port Daniel; at Black Cape, in hollows and on hill slopes; at the largest of the two lakes behind New Richmond, forming banks and damming up its waters; on the slopes of the hills along the Nouvelle valley, especially along the bye-roads to St. Louis Mountain and Parker settlements, etc.

Localities where decomposed rock occurs *in situ*.

In several parts of the district, especially in that tract occupied by Middle Carboniferous rocks to the east of Bathurst, the sandstone and conglomerates, partially disintegrated, can be seen in sections underlying the stratified deposits apparently undisturbed by glacial action. Transported blocks usually overlie these and sometimes boulder-clay, and the facts show that erosion from the ice of the Post-Tertiary period was not sufficiently powerful to remove the whole of the superincumbent decayed rock material from the rock surface beneath. It has, therefore, escaped abrasion, and resting immediately upon it is seen the rotted rock referred to,—the material from which till is formed.

Conclusion with reference to mode of occurrence of till.

Viewing the foregoing facts connectedly, it would seem that till forms the covering of a considerable portion of the solid rocks throughout the district, although largely concealed by stratified deposits. Wherever openings have been made in these, it is seen constituting a sheet of greater or less thickness, and invariably at the base of the series. The thickest beds of till, however, occupy sinuses, or the mouths of river valleys along the coast, or the lee side of ridges or hills which have protected them from denuding agents.

Morainic material.

No morainic material was noticed, except under the kames, where locally it occurs as masses of boulders partially rounded, but still preserving traces of glaciation. The fact that the Post-Tertiary glaciers which occupied the surface of the country, slid down into the Baie des Chaleurs depression, perhaps considerably below the present high water mark, may account for the absence of terminal moraines; but no lateral

ones seem to have been left either, except those referred to forming the bottom of the kames. Morainic beds under kames were observed at Dickie's Cove and in the Nouvelle valley.

Boulders, Erratic Blocks, Etc.

Considerable quantities of loose boulders are strewn over the surface of the district under examination, or imbedded in the till and other deposits. In general they appear, so far as they can be traced to their parent sources, to have been shifted eastwardly, or rather north-eastwardly, in northern New Brunswick, and south-eastwardly in Bonaventure county, Quebec; but there are exceptions to this rule, to which reference will presently be made. The great majority belong to rocks *in situ* in their neighborhood. The presence of large numbers of that almost ubiquitous kind—granite—in the area under review, seems, in some instances, inexplicable, and encourages the belief that the laws or agencies governing their distribution are yet but very imperfectly understood. In the Middle Carboniferous district east of Bathurst, they are scattered about in such profusion as to give rise to the opinion that domes or bosses of the parent rock must have protruded through these strata in places at or immediately prior to the glacial period, although they cannot now be seen. Near Black Rock on the road from Pokeshaw to Millville, the surface in places is abundantly strewn with blocks, many of which are sub-angular and five to seven feet in diameter. Large ones were also noticed at Clifton and New Bandon; indeed, they are met with everywhere in that section,—in the interior, on the coast, on headlands, shores, islands, etc., down to the Gulf. Their occurrence is not so difficult of explanation there as elsewhere, however, as the ice of the glacial period is known to have moved from the south-west, carrying blocks from the granite area south of Bathurst, north-eastwardly in that direction, and the exposure of those occurring on the surface there as in other places, is, no doubt, due to the denudation of the finer and lighter materials.

Boulders; general direction of transport.

Occurrence of granite boulders at great distances from parent rocks.

How transported.

In the district lying to the west and north-west of Bathurst, however, similar granitic boulders and others of crystalline rocks were observed. Those of granite are not so abundant as to the eastward, but are nevertheless, met with at Nigadoo and Elm Tree rivers not infrequently, and sparingly to Belledune and westward. In the interior, at the headwaters of Nigadoo, in the vicinity of the so-called silver mines, they were noticed 500 to 600 feet above sea level. Now, while those along the coast might have been, and probably were carried to their present sites by floating ice during the Post-Tertiary subsidence, having first been moved from the interior towards the coast by glaciers, the

Granite boulders occurring in the interior above the 200 feet contour line.

How brought thither.

granite boulders in the last mentioned locality, which is above the limit of this subsidence, could not thus have been transported. Indeed, it would appear as if the granite area along the Nepisiguit River referred to, had scattered its boulders or debris in every direction around the parent rock, although, as already stated, the blocks are larger and more numerous to the eastward and north-eastward. the direction in which the ice of the glacial period moved after passing over it.

Difficulties regarding presence of granite boulders in the interior of Restigouche county.

The occurrence of occasional granitic and gneissic boulders in different parts of Restigouche county, associated with those belonging to other crystalline rocks, such as diorite, felsite, dolerite, etc., of known local origin, is another question beset with difficulties, according to the generally accepted theories of transportation. Upon the marginal area below the 200 feet contour line, they may have been distributed by floating ice; and the granitic boulders, sometimes noticed in the Restigouche valley proper, may have been borne thither from the Notre Dame or Shickshock Mountains by land ice, similarly to those occasionally met with in different parts of Bonaventure county. But it is not improbable that there are small granite domes or bosses* in the interior, not yet known, which have furnished the boulders now seen sparingly scattered over the surface of the great Silurian plain south and east of the Restigouche River.

Foreign boulders.

It has been stated that no foreign boulders are found in the Gaspé peninsula.† This seems to be true as far as known, except on the low coast area along the St. Lawrence., but the same statement may be made in regard to northern New Brunswick as well, no boulders having been seen there, other than what are at least similar to rocks *in situ* in some parts of the drainage area surrounding the Baie des Chaleurs, whether derived from them or not.

Transportation of boulders in Bathurst harbour.

An illustration of one mode in which boulders are sometimes transported may here be given. In the southern part of Bathurst harbour or basin(which is an estuarine flat) a considerable number of granite blocks, from one to seven feet in diameter, are strewn. These have been moved from the mouth of Middle River, distances of half a mile to a mile within the Recent period, by ice which forms in the basin and river every winter, as it is melted and carried out by the spring floods. This basin is being silted up, nevertheless, the boulders are kept on the surface, being rolled over or moved further down a few inches or feet, as the case may be, every season. Sir William Dawson has shown that boulders are similarly transported in the Lower St.

* Granite occurs on Benjamin River, Restigouche county, which was quarried during the construction of the Intercolonial Railway. See Mr. Ells' report (Report of Progress, 1879-80, p. 47 D.)

† Dr. R. Bell was, I believe, the first to call attention to this fact in a paper published in the *Canadian Naturalist*, Vol. VIII. (1863)

Lawrence valley. In the course of ages, erratics may thus have been moved great distances.

Conclusions respecting the Glaciation of the Baie des Chaleurs Basin and Gaspé Peninsula.

Glaciation how effected in Baie des Chaleurs basin.

The striæ and the direction in which the boulders of local rocks, as well as the till, have been transported, indicate that ice, which mantled the country surrounding the Baie des Chaleurs during the glacial period, moved down the slopes from the north, west and south into its basin. In the Gaspé peninsula, ice probably covered the whole table-land south of the watershed, and was controlled in its flow by the larger river valleys. The hilly tract in the northern part of Restigouche county, drained by the river of that name, was similarly clad with ice, which also followed the courses of the principal valleys. On the southern side of the Baie des Chaleurs, however, from Eel River to Elm Tree River, the ice covering appears to have moved independently of surface inequalities. The land is comparatively low, with an even surface near the coast, and the trend of the ice movement was diagonally across the minor valleys eastward and north-eastward, to the deeper part of the Baie des Chaleurs basin. This fact lends countenance to the view that the ice which flowed down the Restigouche, Nouvelle and Cascapedia valleys, coalesced in the Baie des Chaleurs basin, forming a local glacier which occupied the whole western end of the depression. The portion of the bay lying east of Belledune Point, or Petite Roche, appears, however, to have been open, for the courses of the striæ at Port Daniel and Point Maquereau, as well as on the New Brunswick side at Nigadoo, Dumfries, Bathurst and Bass River, show an ice flow more directly into it, uninfluenced by other ice movements from the west. At Belledune and Elm Tree River, however, later and finer striæ, crossing the deeper grooves at a wide angle, indicate that smaller local glaciers, debouched into the bay after those referred to had retired, or they may have been produced by icebergs.

Striæ in Quatawamkedgwick and Metapedia river valleys.

The striæ observed in the valleys of the Quatawamkedgwick, Metapedia (see list of striæ, Geology of Canada, 1863, p. 892, No. 139), and Nouvelle indicate, as stated above, that glaciers flowed down these; and the facts when correlated with observations made on the south side of the St. Lawrence, referred to on previous pages, afford proof that the existing watershed of the Gaspé peninsula, and of the region to the south-west shed the ice which accumulated on it northward and southward, as it now sheds the waters due to precipitation.

No positive evidence regarding the striating action of the icebergs

Action of icebergs or floating ice.

of the glacial epoch was obtained around the shores of the Baie des Chaleurs, except it be such as is referred to above, occurring at Belledune and Elm Tree River. That icebergs have been instrumental in the transportation of boulders, however, seems beyond question. The blocks met with near the coast, which have been carried from the parent beds in a direction contrary to that of the ice-flow, were, no doubt, moved by them. Moreover, although proof is wanting that icebergs have produced striæ on rock surfaces, they appear to have had a powerful denuding effect, along with coast and pack ice, especially on the southern side of the Baie des Chaleurs. It has been already stated that the coast area, east of the Dalhousie hills, presents a uniform surface, sloping at a low angle from an elevation of 200 to 300 feet down underneath the waters of the bay; and that while the strata are much folded and crumpled, and cut by dykes of diorite, and other eruptive rocks; they have all, nevertheless, been denuded and planed off nearly level. Obviously, therefore, other agencies as well as the sea and land ice have been in operation here, levelling the surface. And it seems almost beyond a doubt that these have been coast and floating ice and icebergs of the Post-Tertiary and preceding ages, if we may suppose such to have existed. That the erosion here witnessed must have been prior to the final melting of the glaciers is shown by the presence of striæ still retained by the rock surfaces.

Effects of floating ice at present day.

The effects of coast and floating ice can be observed even at the present day in the same locality. Easterly winds drive in packs every winter and spring, pushing them against the shores of the southern side of the Bay, levelling down the zone between high-water mark and the ten to fifteen feet contour line below it. Similar erosive agencies have undoubtedly been in operation for long ages, as the coast area oscillated in level, which would be intensified when the waters of the Baie des Chaleurs covered a larger area. That the chief denudation which the surface of the district underwent was, however, pre-glacial and sub-ærial, admits of no question; but the agencies referred to serve to explain the uniformity of surface which the latter could not effect.

Stratified Inland Gravel, Sand and Clay.

Stratified inland gravel, sand and clay, where found.

Everywhere outside of the river valleys, above the 200 feet contour line, deposits of stratified gravel, sand and clay occur, forming the largest portion of the cultivable soil within the area mapped. For the most part, these beds are quite thin, usually resting on the till or rock debris; but on slopes and in hollows they are often a foot or more in thickness, constituting lenticular sheets, more especially the clayey portion, which appears to have been washed down from the hills and ridges

wherever there are rolling or uneven surfaces. The chief agent in stratifying or remodelling these from pre-existing beds was, no doubt, the waters resulting from the melting of the snow and ice of the glacial period, at or near its close. In certain hollows, lakes or ponds existed at that time, which have since dried up from drainage or evaporation. Streams also flowed through nearly all the minor valleys then, where now they may be seen only for a short time during the melting of each winter's snow. These would be important agents in remodelling the surface materials. Over a large part of the district mentioned, however, these inland surface deposits are really till, or the rock debris from which till is derived, with the upper portion oxidized and partially modified through atmospheric action such as rain, frost, melting snow, etc., and by the rooting of plants and their decay. Wherever the surface was irregular, these agencies, by loosening the soil, would keep it in such a condition that it could be readily moved from higher to lower levels by ordinary sub-ærial processes, so that, in the lapse of ages, these apparently insignificant means would result in changes of great importance as regards these surface beds. As illustrating the character and depth of these inland deposits, the following sections may be instructive :— How formed.

1. At the confluence of the Metapedia and Restigouche rivers, in a hillside, a stream of water from a bursting reservoir cut a channel into the surface beds six to ten feet deep, exposing the rock surface beneath, which was not glaciated, and affording a good section. The principal mass was seen to be local rock debris, unstratified, and apparently formed *in situ*. The uppermost twelve to fifteen inches were, however, oxidized and partly stratified from the materials sliding down hill. Section of stratified inland deposits at Metapedia.

2. In St. Alexis settlement, which has a rolling surface 800 to 1000 feet above the sea, the deposits are :— St. Alexis.

(1) Stratified sand, gravel, or clay on the surface, from two or three inches to a foot or more in thickness.
(2) Till in places, but sometimes rock debris resting on the upturned ragged edges of the fragile, decaying Silurian slates. The till, oxidized on the surface, seems to cover, indeed, a large part of the district.

3. On a hill behind Paspebiac, 210 feet high, the surface deposits are somewhat similar, viz:— Paspebiac.

(1) A few inches to a foot or more of oxidized and modified rock debris finely comminuted by atmospheric action, and in places stratified.
(2) Decayed rock material,derived from the underlying Lower Carboniferous sandstones, which, for the most part, has been changed to till by glacial action.

River Terraces.

River terraces.

The river valleys in this district are all terraced throughout at various heights, the terraces all corresponding in size with the rivers, as stated in previous reports, except near their mouths, where they are of marine formation. The Restigouche and its larger affluents, and the Nouvelle, Cascapedia, Bonaventure, etc., exhibit terraces of greater or less extent. On the Restigouche, the highest are at the following places, (the heights, unless otherwise mentioned, having reference to that of the river at the nearest point).

Occurrence of terraces along Restigouche River and its branches.

1. Red Pine Brook, a terrace 20 to 30 feet, another 30 to 40 feet high. These are narrow and somewhat uneven.
2. Mouth of Patapedia on left bank, a terrace 50 feet high.
3. On opposide side of Restigouche, a terrace three-quarters of a mile long, kame-like, and also about 50 feet high. This terrace extends up the Restigouche valley, on one side or the other, nearly to White's Brook.
4. Opposite Stillwater Brook, terraces are seen 20 to 30 feet high, forming the point in the river bend here.
5. In Quatawamkedgewick valley, below Falls Brook, terraces are seen 20 to 30 feet high. None higher than these occur on this river.
6. On Patapedia, the terraces do not exceed 20 to 30 feet in height, and are all narrow.
7. Terraces near the mouth of Upsalquitch, on that river, are 20 to 40 feet high. Further up they are usually lower, except at the upper falls, six to seven miles below Upsalquitch Lake (see preliminary re-report GG, Annual Report, 1885).

Along Metapedia River terraces occur at the mouth of Assemetquagan twenty to thirty feet high, but narrow. At Milnekik branch they are thirty to thirty-five feet high, and extend along Metapedia one to two miles. Above that, to Assemetquagan station, Intercolonial Railway, they are narrow and not more than ten to twenty-five feet high.

No noteworthy river terraces were observed on other rivers within the limits of the maps; and the above represent the highest in the district, except it be at waterfalls.

Marine Terraces and Kames.

(*Saxicava Sand and Leda Clay*).

Marine terraces.

Marine or sea-border terraces were met with all around the Baie des Chaleurs, and often extending up river valleys many miles. The Restigouche exhibits these formations as far up as the confluence of the Upsalquitch, thirty-six miles from its mouth, and the Metapedia,

as far as Millstream branch. The Cascapedia, Nouvelle, and Bonaventure valleys are likewise terraced with marine deposits for considerable distances, the former especially beyond the limits of the map. Where found.

A marked difference exists between these and river terraces as regards elevation and area. For example, on the Restigouche and its affluents, no river terraces occur higher than 40 to 50 feet above the stream alongside of them; but as we approach its mouth, especially within five to fifteen miles of tide head, we find marine terraces 150 feet high or more. The same distinction holds good with reference to river and marine terraces on the Nouvelle, Cascapedia and Bonaventure rivers. These elevated terraces, although formed in estuaries or tidal inlets during the Post-Tertiary submergence, and leveled off by the sea, have nevertheless derived the material which composes them from the rivers; in other words, they have been formed of river detritus at or near the head of tidal waters during the Post-Tertiary subsidence. Difference between marine and river terraces.

The terraces found around the coast of the Baie des Chaleurs likewise consist of the debris of the rocks within its drainage basin, and have been modelled chiefly by the sea. No well defined ones were observed at a greater elevation than 175 to 200 feet above tide level, unless it may be some occurring at Port Daniel, described below. Fossils are found in nearly all these terraces, being most abundant, however, around the mouth of rivers, and within the area of the Silurian limestone. Material, elevation and mode of formation.

Marine terraces are invariably formed of (1) Saxicava sand, which changes on the one hand into a coarse gravel or detritus with small boulders, and on the other, to fine sand without admixture of other material; (2) Leda clay, fossiliferous in the uppermost strata, the whole usually resting on till, rock debris, or occasionally on kames. Saxicava sand and Leda clay.

Over a large part of the area under review, these marine deposits (Saxicava sand and Leda clay), are not regularly terraced, however, but occur as thin or lenticular sheets upon the surface of the boulder-clay, or rotted rock material, as the case may be. And, although from the elevations of the terraces under discussion it is evident the sea has invaded the region to a height of about 200 feet above the existing sea level, yet long stretches of the coast area below the 200 feet contour line bear no traces of submergence. Certain tracts on the New Brunswick side of the Bay may be mentioned, as for example, (1) between Jacquet and Tête-à-gauche rivers, and (2) east of Bathurst to the limits of the map. These slope down to the shore, and are unterraced, except at the mouths of the rivers and brooks. In Bonaventure county a similar want of terracing is apparent in many localities. The facts tend to show that terracing has taken place, as stated, chiefly at or near the mouths of rivers, and that these have supplied the principal portion of the material. Absence of marine terraces along coast in certain localities.

Section of marine deposits.

In the unterraced coast areas, below the 200 feet level, the beds, so far as examined, consist of the following series:—

1. Saxicava sand or gravel, with boulders and travelled blocks of various sizes. Deposit generally thin.
2. Leda clay; thin but sometimes in lenticular sheets of a few feet in thickness. Seldom containing fossils.
3. Boulder clay or rock debris, of various depths.

Leda clay resting on till.

Often, however, one or the other of the series is wanting. A fine example of Leda clay overlying and resting on till, the latter with a smoothed surface, can be seen at Miller's Crossing, Intercolonial railway.

Description of marine terraces.

Following is a description of the principal marine terraces. The elevations are referred to high tide level, and the courses of kames, etc. to the true meridian.

Bathurst.

1. Extensive terraces occur around Bathurst harbour, stretching eastward to Salmon Beach, and westward to Peter's River, occupying an area of not less than twenty-five square miles. They are considerably denuded by the four rivers which here flow into this harbour; but the elevation of the upper ones is 125 to 175 feet, reaching 190 feet in the rear of St. Ann settlement, and along Tête-à-gauche River. Fossils are found in them at Bathurst and Tête-à-gauche.

Jacquet River.

2. Around the mouth of Jacquet River and extending westward to Nash's Creek and some distance beyond it, a series of terraces occurs, the highest of which is 150 to 175 feet. These are likewise much denuded. Fossils at Jacquet River and Louison Brook.

Charlo River.

3. Well-defined terraces occur around the mouth of Charlo River, rising, at the distance of two miles from the shore, to a height of 150 feet, and in Mountain Brook settlement, between Charlo and Eel rivers, 165 feet. Fossils.

Along Restigouche River, south side.

4. In the Restigouche valley (south side) terraces occur in the following places:—At Campbellton, 10 to 30 feet high, with fossils; at Christopher's Brook, extending up that stream to Glencoe and Glenlivit settlements, the highest one being at the end of the Glencoe road, 180 to 200 feet; at Flatlands, along road to Glenlivit settlement, another 160 feet high, and at Dawsonvale a narrow one 180 to 190 feet high, a short kame parallel to Rafting-ground Brook standing upon it.

Runnymede.

5. Returning, on the north side of the Restigouche valley we find at Runnymede a series of terraces along the face of the slope behind the flat which occurs here, 75 to 90 feet high; three to four miles further down, another series, the highest about 90 feet, with fossils (*Mya* and *Macoma*) in lower ones; at mouth of Metapedia, several terraces. Fossils. (See Annual Report, 1885, p. 45 GG., for section of these.)

Metapedia River.

6. Along Metapedia River, opposite mouth of Mill-stream, a ter-

race occurs 70 to 75 feet above that river, or about 200 feet above the sea, extending along the valley several miles, although not more than 100 to 200 yards in width. If this terrace was formed when the Metapedia valley was flooded by the sea, as is assumed, it marks the upper limit of the Post-Tertiary submergence here. Farther down the valley lower terraces skirt it on one side or the other till it joins the Restigouche.

7. Just below the mouth of Sellar's Brook, a terrace 175 to 180 feet high occurs, and others are seen stretching along the river a mile or two farther down; also at the mouth of Little River and at Bourdo, terraces are found at different elevations, but none high. Sellar's Brook to Bourdo.

8. At Oak and Battery Points terraces 150 feet high lie behind the kame seen at these places. Fossils. Oak and Battery Points.

9. Terraces are met with at Harrison's Brook and along the shore towards Scaumenac River; also, up the river about three miles, one 140 to 150 feet high was seen. Scaumenac River.

10. On the west side of Nouvelle valley, along the main road, three well-formed terraces were observed, the highest 150 feet. Those extend down river two miles or more; also, two to two and a half miles above the middle bridge, on the east side, another a mile or more in length and about 125 feet high; and a third behind kame No. 3, described below, stretching towards foot hills at a height of 80 to 100 feet. Other lower terraces intervene on river-ward side of kame. Nouvelle valley.

11. Behind Shoolbred, terraces skirt the base of the mountains at varions elevations, but none exceed in height those just described. Shoolbred.

12. Two to three miles west of Carleton a terrace 125 to 140 feet high is seen between a rocky ridge and the mountains. Carleton.

13. East of Carleton, extensive terraces extend from the lagoon inside of Carleton Point to Maria, six or seven miles, and from the shore back to the foot-hills (see map); height 130 to 140 feet. The highest or outer margin of these forms kame No. 4, called Maria Capes. Along base of mountains another narrow terrace rises to a height of 175 feet. Fossils. Carleton Point to Maria.

14. Behind Maria P.O., along Green's Brook, extensive terraces likewise occur at elevations of (1) 50 to 75 feet, (2) 110 feet, and (3) 175 feet, the latter close to foot-hills. Green's Brook.

15. At Blue Lakes, Irishtown, terraces 150 to 175 feet high are found, in which some of these lakes lie. They extend along the banks of Manderson's Brook and around certain hills between that and Cascapedia River, (see map). Irishtown.

16. Extensive terraces border the Cascapedia River as far up as the limits of the map, and beyond it, the highest rising 150 to 175 feet above sea level. The terrace on the left bank for five miles up from Cascapedia River.

the river's mouth has been cut into a magnificent kame (kame No. 5).

Little Cascapedia River.

17. Terraces occur on the left bank of Little Cascapedia River, three miles up from the main post road, 150 to 180 feet high.

Capelin.

18. Behind Capelin wide terraces were seen at different elevations, highest 190 feet. Some of these are, in reality, benches made in the Lower Carboniferous rocks, but are, nevertheless, covered by water-worn gravel.

Bonaventure River.

19. Along Bonaventure River, west side, wide terraces, 65 to 75 feet high, extend; and on east side, going up the road to back settlements, four terraces were seen in succession, at heights of 50, 70, 100 and 150 feet, the last one narrow.

Port Daniel.

20. On the west side of Port Daniel, terraces occupy a considerable area, the highest of which are 225 to 240 feet. They are underlaid by Lower Carboniferous rocks, however, and their terraced appearance may be owing to the horizontality of these; but they certainly have rolled, water-worn gravel on their summits. No fossils were found in them.

Anse à la Barbe.

21. At Anse à la Barbe, a terrace was observed 100 to 125 feet high, much denuded by the stream.

Many others, not here noted, occur in the district, but the foregoing will exemplify the extent and elevation of the marine terracing, and the subsidence the region underwent during the Post-Tertiary period.

Marine Kames.

Marine kames.

These kames, which usually occur along with the terraces last described, have been met with in the following localities:—

Restigouche kame.

1. The Restigouche kame extends along the coast from Charlo River to Nash's Creek. (For description, see Annual Report, 1885, p. 30 G G.)

Battery Point.

2. A kame about one and a half miles long extends from Oak Bay to Battery Point, in the Restigouche estuary; course about N. 80° E.; height 150 to 175 feet. River-ward face steep, but inner side slopes away towards hills at a low angle. It consists of a series of hummocks.

Nouvelle.

3. In Nouvelle valley, a kame stretches from the R. C. Church to the river's mouth, three and a half to four miles; course S. 50° E. or parallel to valley; height, 80 to 100 feet. River-ward face steep. This kame is really the high outer margin of a terrace.

Maria.

4. This kame, like the last, is also the high border of a wide terrace, and consists of a series of hummocks stretching along the coast between Maria and Carleton, a distaace of fully five miles. Course nearly S. W. and N. E.; height 140 to 150 feet. These ridges and hummocks are widest at the northern end.

Cascapedia.

5. This kame, already referred to, which extends along the east side

of the Cascapedia for five miles, is the finest in the Baie des Chaleurs basin. Course N. and S.; height 100 to 150 feet. It is wider and higher at the upper end and terrace-like in places, being, in fact, a denuded terrace, worn away by the river on one side, and by several small streams, tributary to it, on the other. These, as the land emerged from the Post-Tertiary sea, flowed in a direction nearly parallel to the river for some distance, eroding the east side of the kame.

6. Between two small lakes behind New Carlisle, the larger of which is called Dark Lake, a kame extends one and a half to two miles, holding up the waters of the other fifteen feet above it. Course N. 75° E. Height of Dark Lake, 160 feet. Gravel ridges or kames, the summits of which are 190 to 200 feet high, encompass these lakes. New Carlisle.

River Flats or Intervales.

These formations embrace the lowest of the terraces or steps along river banks, and are distinguished from the latter, on account of their being annually or periodically overflowed by freshets. They seldom rise more than eight or ten feet above the ordinary summer level of the rivers, and are capped by loam of varied texture, from a few inches to several feet deep. In some of the lower intervales, nothing, except the loam, is visible; but in making openings in them, gravel beds, and in some cases, clay, are found underneath. They occur in all river valleys above tidal waters. Those flats which are met with near the mouths of rivers, below the 200 feet contour line above sea level, are, however, partly of estuarine and partly of fluviatile origin. During the Post-Tertiary subsidence, marine beds consisting of Leda clay and Saxicava sand, often holding sea shells, were deposited in river valleys above existing tidal waters in what were then estuaries; but on the emergence of the land subsequently, the rivers again flowed over these estuarine bottoms, eroding them and depositing sand, loam, etc., upon them in certain places. Sections of these flats would show the stratified portion of the beds to consist of: (1) loam or fine sand, (2) river gravel, (3) Saxicava sand, (4) Leda clay, etc. They were generally of wider area than those intervales solely of fluviatile formation occurring in the interior, and comprise the very best farming land in the district. River flats, occurrence and mode of origin. Section of these.

Along the rivers within the region mapped, the most extensive intervales, altogether of fluviatile origin, are found on the upper Restigouche at the confluence of the larger tributaries, such as the Quatawamkedgewick, Patapedia, Upsalquitch, etc. As they are met with, however, on almost every river and stream of any size, only the largest and most important will be here described, and all river-flats will be classed together in this report, reference being made particularly to those underlain by marine deposits:— River flats on Restigouche and other rivers.

Tête-à-gauche River.

1. Near the mouth of the Tête-à-gauche River, at Somerset Vale farm, excellent intervales, dotted with elms, maples and clumps of spruce, may be seen. These have marine beds underneath.

Marine and fluviatile flats (intervales) along the Restigouche River.

2. In the Restigouche valley, fine intervales occur at Athol House, Flatlands, Metapedia and Runnymede, which are partly marine, while others, altogether of fluviatile origin, were observed at Deeside, Patapedia, Tracy Brook, Quatawamkedgewick, etc., being usually of greater extent at the mouths of these affluents. In many places, these flats are half a mile or more in width, and form excellent soil. Along the chief tributaries of the Restigouche, flats of considerable area likewise occur, but usually narrower than on the main river. On the Upsalquitch, near its mouth, a fine intervale two to three miles long was seen, and another occurs at the confluence of the north branch.

Nouvelle.

3. In Nouvelle valley an excellent intervale stretches from tide-head three to four miles up, beyond which there is a constriction in the valley. Above this another occurs, called the "big flat."

Cascapedia.

4. Along the Cascapedia, intervales and islands extend as far up as the limits of the map and beyond it. They comprise a number of good farms, and are nearly all cleared and occupied.

Little Cascapedia.

5. A wide flat is found on the east side of the Little Cascapedia, extending up the valley as far as the road goes. (See map.)

The intervales described as occurring along the last three rivers, consist of Leda clay and Saxicava sand overlain by loam of fluviatile formation.

Bonaventure.

6. Along Bonaventure River intervales stretch from the head of the tide, at a varying width, to within a short distance of the mouth of Duval River. In the vicinity of the mouth of Hall's River, there seems to be a considerable area of good bottom land. The larger portion is still covered by forest.

Port Daniel.

7. The Port Daniel River is skirted along its several branches by narrow flats of limited area. Except for a short distance up the East River, the district traversed by these streams is also covered by forest.

Lacustrine and Fluviatile Marshes.

Lacustrine and fluviatile marshes.

Deposits of this character are of very limited extent in the district included in the maps, owing to the fact that the lakes are small and the rivers rapid, usually flowing over gravelly bottoms. Narrow belts of marsh fringe the lakes behind New Carlisle, also those near Campbellton, and along the head waters of the various rivers. The larger lakes at the head of Patapedia and Métis rivers were not visited; but from the information gathered they appear to be partially bordered by marshy grounds.

Wherever there are "dead waters" at or near the sources of rivers or brooks, small marshes or peaty areas skirt them.

Sand Dunes.

Sand dunes occur at Pokemouche gully and Point Mizzenette, also along the shore from the latter place to Blue Cove. Alston and Carron Points, at the entrance to Bathurst harbour, are of this character, while Belledune and Little Belledune Points, Eel River bar, and Carleton and Paspebiac Points, which are all formed of sand thrown up by the waves, enclose lagoons into which the tide flows. Other accumulations of sand are met with at the mouth of Jacquet River, and at Nouvelle and New Carlisle. A sand spit is also in process of formation on the inner side of Heron Island. The mode of origin of these sand beds has been described in the preliminary report referred to, 1885. Sand dunes, where found.

Shell Marl.

Shell marl is found at Belledune, near the shore, underlying a peaty deposit; also at Charlo River, in the bottom of a lakelet, where it is fully exposed, and is reported to be nine feet deep. The farmers in the vicinity of the latter place sometimes cut holes in the ice during winter, and dig it up for fertilizing the heavier clay soils overlying the Lower Carboniferous rocks there. In New Richmond, marl also occurs in a lake bottom (see map) in the third concession. In none of these localities, however, is it used in any great quantity for fertilizing purposes, owing to the lime already in the soil, derived from the subjacent calcareous slates (Silurian), which renders its application, to a large extent, unnecessary. Shell marl, localities of.

Peat Bogs.

Peat bogs, which are sometimes, when large, called "caribou plains," are common in the district occupied by the Middle Carboniferous rocks, on the south side of the Baie des Chaleurs, owing chiefly to insufficient drainage, resulting from the flatness of the surface. On the Silurian uplands they are less numerous, and are usually of smaller area. No attempt has been made to utilize peat in any way in this part of the country. For a description of some of the more accessible of these beds, see the preliminary report above referred to, page 47 GG. The following bogs or peaty barrens were noted during the season of 1885: Peat bogs.

1. A bog occurs in the middle of the peninsula terminated by Point Mizzenette, Gloucester county. Two small lakes lie in it which are drained by a little stream into Blue Cove. Point Mizzenette.

2. About half a mile north of the Waugh River, at Pokemouche, the road crosses a peat bog half a mile long and about 200 yards wide. Waugh River.

St. Simon's Inlet. 3. At the southern end of the road going from Lower Caraquette to St. Simon's Inlet a small bog crosses it.

Pokemouche gully. 4. A bog or "cranberry barren" of considerable extent occurs south of Pokemouche gully, skirted by salt marsh (see map).

Belledune. 5. A small peat bog is seen at Belledune, just south of the point.

Charlo River. 6. A similar one occurs east of the mouth of Charlo River. (These two, Nos. 5 and 6, are mentioned in the preliminary report. p. 47 GG.)

Bonaventure. 7. Peaty areas are of frequent occurrence on the surface of the Lower Carboniferous rocks in Bonaventure county, but they are of little depth, and generally form cedar swamps. One of these is crossed by the first road going to the second concession north of Bonaventure River, and seems to be of considerable extent.

Cullin's River. 8. A small peat bog was seen along the road going back on the south side of Cullin's River.

New Carlisle. Similar small bogs were observed around the margins of the lakes behind New Carlisle and elsewhere.

Salt Marshes.

Salt marshes, localities and area. Deposits of this character border some of the peat bogs just described, and skirt the shores and estuaries in numerous localities around the Baie des Chaleurs. A few of them produce hay, which is cut, and two or three are dyked. Unless in the Carboniferous area, in the eastern part of Gloucester county, they are narrow and unimportant, and much intersected by lagoons. At Caraquette and Pokemouche. Pokemouche, however, some of them yield quantities of hay. The localities of the larger of these marshes will here be given.

1. Around Pokemouche gully, skirting the cranberry barren referred to, and at St. Simon's Inlet, marginal areas of these are seen, some of which yield hay.

Caraquette. 2. In Caraquette harbour they occur also in several places, for example, at the western end, around the mouths of Caraquette River and Symond's Brook (see map). The one at the former place lies chiefly on the south side, and below the bridge is a quarter to half a mile wide; that on Symond's Brook is a quarter of a mile or more wide at the bridge, and one and a half to two miles long.

3. At the mouths of Peter's River and Grant's Brook, inside of the sand barrier, small patches of marsh occur.

4. Inside of Eel River sand bar, narrow beds of this kind skirt the lagoon.

Restigouche estuary. 5. In the Restigouche estuary, areas of marsh border it at Athol House, and below Cross Point.

Nouvelle. 6. Around the estuary of Nouvelle River they are seen one to two miles long, and 200 to 300 yards wide on each side.

7, On the east side of Little Cascapedia River, around tide head, deposits of this character also occur. Cascapedia.

8. In Bonaventure River estuary, salt marshes skirt the terraces all around. Bonaventure.

Other localities, such as Bathurst Harbour, Tête-à-gauche estuary, and around the lagoons, inside of the sand dunes at Belledune, Carleton, Paspebiac, etc., also Jacquet River estuary, part of the west end of Heron Island, a marginal strip at Shoolbred, and another at Maria, a patch near mouth of Little Bonaventure River, and another at the mouth of Nouvelle River (Shigawake) might be enumerated as exhibiting salt marshes of limited areas; but in most cases they are mere selvages, too small to map, and not of sufficient importance to describe. Other localities.

Estuarine Flats.

Estuarine flats are formed of deposits, chiefly detrital and fluviatile, which have been laid down in harbours, inlets and mouths of rivers, the surface of which is littoral, that is to say, is flooded at high tides and laid bare, or nearly so, at the ebb. They are largely composed of river silt, (fine sand and clay); but sometimes coarser material is found in them; and they are always partly covered, at least, with eelgrass (*Zostera marina*) and other sea or brackish water plants. The principal places where they have been noted are:— Estuarine flats, character of. Principal places where noted.

1. In Pokemouche Harbour, skirting the shore.
2. At Point Mizzenette, inside Caraquette Harbour.
3. In Bathurst Harbour, covering nearly the whole basin.
4. Inside of Restigouche estuary, from Point La Lime to the head of the tide, and occupying a large part of this area.
5. In Cascapedia Bay and estuary, also at mouth of Little Cascapedia River.
6. At mouth of Bonaventure River, and
7. Around the Port Daniel basin, in marginal flats.

These estuarine flats, more especially at Pokemouche and at the Restigouche and Cascapedia Rivers, form feeding grounds for the wild geese and brant (*Bernicla Canadensis* and *B. brenta*) which frequent this region in great numbers every spring and autumn.

Agricultural Character, Flora, Fauna, etc.

A general description of the agricultural character of northern New Brunswick was given in the preliminary report already several times cited, and the geological relations and mode of origin of the soils and subsoils discussed in some detail. It was shown that the passage of glaciers over this region, from west to east, had distributed large quanti- Agricultural character of region: where described.

General character of materials constituting soil.

ties of the coarse debris of the eruptive rocks (dolerites, felsites, diorites, etc.), which form dykes in the Silurian strata, and that, consequently, the land was stony in many places, especially near the coast. In Bonaventure county, a similar condition of things prevailed, and the great denudation the district underwent seems to have removed large portions of the finer material into the valleys, and the depression of the Baie des Chaleurs, leaving the coarser gravel and boulders in the soil. Notwithstanding this, however, there are excellent tracts of farming lands on the northern side of the bay, which will be more particularly referred to further on, and on the whole, it may be stated that its agricultural character is higher than that of the New Brunswick side. In the following brief description it is considered advisable to refer to each geological formation in the district mapped separately, showing, as nearly as possible, the relations existing between it and the superincumbent soil. The Silurian being the largest and most important area, a description of the soil resting upon these rocks will first claim attention.

CHARACTER OF SILURIAN UPLANDS.

Elevation, extent and quality of Silurian uplands.

The general aspect of the surface over all this large tract on both sides of the Baie des Chaleurs and Restigouche valley, is rolling, but it is deeply trenched by the rivers and streams which traverse it. As has been stated in previous reports, the portion of these uplands lying north and west of the Restigouche is almost entirely a table-land, varying in elevation from 800 or 900 feet to 1500 feet above sea-level, the height increasing northwards. Tracts of comparatively level land are, however, found between the river valleys on which the soil is often deep, generally free from stones, and fertile, the materials of which it is composed having been derived, in a large measure, from the rotting of the underlying Silurian slates. Unfortunately, not much progress has yet been made in forming settlements upon these Silurian uplands, their remoteness, want of roads, and other drawbacks operating against it. In Restigouche county, two or three settlements have been located upon them, however, and although meeting with difficulties and adverse circumstances at first, have recently been more successful. These are Balmoral, Blair Athol, Becketville, etc., in which, it may be remarked, the soil, although fertile, is somewhat stony, owing to their proximity to large trap dykes, and not by any means to be compared in agricultural value to that of the larger area of these lands in the interior. The people in these settlements are now, however, making substantial progress, the land, in addition to its good quality, being well wooded and watered, and having good natural drainage.

Settlements established on them.

St. Alexis, progress of.

In Bonaventure county, a thriving new settlement called St. Alexis,

has been established on these table-lands, about seven miles west of the mouth of Metapedia River. Here, their height is 900 to 1000 feet above the sea, and the surface is undulating and comparatively free from boulders. While the clearings were small and confined, summer frosts prevailed to some extent; but latterly, these have not recurred so frequently, owing, probably, to the larger acreage of cleared land admitting a freer circulation of air. Indeed, it may be stated as a rule, that summer frosts occur oftener in valleys, and especially along water courses at some distance from the sea coast, than on these table-lands. A greater drawback is the increased quantity of snow which falls there, compared with that of the coast district, and which usually remains later on the ground in spring. Grain is later in maturing also, especially wheat; but all kinds of crops grow well. Upwards of one hundred families have taken up farms in this settlement, and are industrious and hopeful. **Summer frosts and snow-fall.**

Settlements have been located also at Little River and in one or two localities east of the Nouvelle valley, which are fairly prosperous, but they do not appear to have thriven like St. Alexis. **Little River and Nouvelle.**

Limestone is abundant in the Silurian area, and deposits of shell-marl occur in certain localities; but the former is burned only in small quantities, and is very seldom applied to the land. Only at Port Daniel is limestone quarried to any considerable extent, and from there it is shipped to Prince Edward Island, to be used chiefly for fertilizing purposes. **Limestone and shell-marl in Silurian area.**

The chief trees found growing on the drier parts of the Silurian uplands, are, in the order of their relative abundance, as follows:— **Chief trees on Silurian uplands.**

White spruce (*Picea alba*)	2 to 2½ feet in diameter above the roots.		
Black birch (*Betula lenta*)	2 to 3	"	"
Rock maple (*Acer saccharinum*)	2 to 2½	"	"
Balsam fir (*Abies balsamea*)	1 to 2	"	"
White birch (*Betula papyracea*)	2 to 2½	"	"
Do (*B. alba*, var *populifolia*)	1	"	"
Yellow birch (*B. lutea*)	1 to 1½	"	"
White pine (*Pinus strobus*)	2 to 3	"	"
Red pine (*P. resinosa*)	1 to 2	"	"
Beech (*Fagus ferruginea*)	1 to 2	"	"
Poplar (*Populus tremuloides*)	2 to 2½	"	"
Do (*P. grandidentata*)	2 to 2½	"	"
Red oak (*Quercus rubra*)	3 to 6 inches	"	"
Rowan tree (*Pyrus Americana*)	3 to 9 "	"	"
Ground hemlock (*Taxus baccata*)	1 inch or less	"	"

On the lower grounds and in swamps, the following species occur. They are also enumerated in the order of their abundance, the size given being the maximum attained:— **Trees on lower grounds.**

White cedar (*Thuja occidentalis*)	1 to 3	feet in diameter.	
Hacmatac (*Larix Americana*)	1 to 2½	"	"
White birch (*Betula papyracea*)	1 to 2	"	"
White ash (*Fraxinus Americana*)	1 to 2½	"	"
Black ash (*F. sambucifolia*)	1 to 1½	"	"
Red maple (*Acer rubrum*)	1 to 1½	"	"
Black spruce (*Picea nigra*)	1 to 1½	"	"
White spruce (*P. alba*)	1 to 2	"	"

Arrow-wood (*Viburnum*) 2 or 3 species 1 to 2 inches in diameter.

Trees along banks and intervales.

Along river banks and growing on intervales, the following trees are met with :—

Elm (*Ulmus Americana*)	often 2 to 3	ft. in diam.	above the roots.
Balsam poplar (*Populus balsamifera*)	2 to 3	"	"
White spruce (*Picea alba*)	1 to 2	"	"
White cedar (*Thuja occidentalis*)	2 to 3	"	"
Balsam fir (*Abies balsamea*)	1 to 2	"	"
White birch (*Betula papyracea*)	1 to 2½	"	"
White ash (*Fraxinus Americana*)	1 to 2	"	"
Black ash (*F. sambucifolia*)	1	"	"
Red Maple (*Acer rubrum*)	1	"	"
Rowan tree (*Pyrus Americana*)	3 to 9	inches	"
Alder (*Alnus incana*)	1 to 3	"	"
Willow (*Salix*) several species	1 to 3	"	"
Red osier (*Cornus stolonifera*)	1	" or less	"
June-berry (*Amelanchier Canadensis*)	1 to 3	"	"

On the dry banks and slopes of valleys, the following species are often found in addition to others enumerated above :—

Red pine (*Pinus resinosa*)	1 to 1½ feet in diameter.	
Sumach (*Rhus typhina*)	1 inch or less	"

Around the margins of clearings the undermentioned species may be seen in most places : —

Hazel nut (*Corylus rostrata*) 1 inch or less in diameter.
Elder (*Sambucus*) 2 species, 1 to 2 inches "
Cherry (*Prunus*) 2 or 3 species, including the choke cherry, 2 to 6 inches in diameter.

On sand dunes, Juniper (*Juniperus Sabina* var. *procumbens*) may often be found,—a low prostrate shrub half an inch or less in diameter.

Character of trees on Upper Restigouche and affluents.

In the region drained by the Upper Restigouche and its tributaries there is generally a heavy growth of trees, such as spruce, birch, maple, elm, poplar, cedar, etc., the three last being often seen along the rivers, three feet or more in diameter. Large tracts here are still covered by the "forest primeval," apparently untouched by the lumberman's axe. Fires have consequently done less damage than elsewhere in New Brunswick, a few miles in the vicinity of Stillwater Brook being the only burnt woods seen along the main river. The Patapedia valley,

however, has been swept by fires for upwards of twenty miles some years ago, and large tracts there present only bare trunks and "blow-downs," with a scanty undergrowth. As a result of this, blue-berries (*Vaccinium Canadense*) abound, and in autumn bears are numerous.

Character of soil overlying Devonian Rocks.

Soil upon Devonian rocks.

The area of these rocks within the district mapped, is so limited, and the deposits derived from them are consequently so intermixed with those belonging to contiguous formations, that they really cannot be said to have a distinct character of their own. The rocks being largely composed of silicious and trap conglomerate, crumble down into a coarse, stony soil, as is seen wherever the debris resulting from their waste predominates. Small tracts of this kind occur at Scaumenac, Nouvelle and New Richmond.

Soil overlying Lower Carboniferous Rocks.

Soil overlying Lower Cariboniferous rocks; excellent quality of.

Lower Carboniferous sediments occupy coastal areas all around the Baie des Chaleurs, and, although in the aggregate, only of limited extent, yet from the fact that the tracts underlaid by them have nearly all become occupied by settlers, they are of considerable importance in an agricultural point of view. These rocks occur in the vicinity of Bathurst, but are so masked with fluviatile and marine deposits that their influence on the overlying soil there is almost wholly obscured. Around Eel River basin, extending to Charlo River, on the one hand, and to the Restigouche, at Shaw's Cove, on the other (see geologically coloured map), a small area of those rocks is found; Heron Island is also formed of them, and in Bonaventure county, a belt of the Lower Carboniferous stretches from Scaumenac and Maguasha eastward, with a few interruptions, to Port Daniel. Between Black Cape and the latter place they are of sufficient width to give to the soil derived from and resting upon them distinct qualities. The strata, for the most part, occupy their original horizontal position, and the district underlaid by them is consequently flat. Moreover, as these rocks, when ground down, often produce clay, which at the depth of a few inches, forms a "hard-pan,," the soil is often wet, and boggy or peaty areas are of frequent occurrence, owing to insufficient drainage. When the surface has sufficient slope, to afford a natural drainage of the surplus waters due to precipitation, however, the land is excellent, being friable, easily cultivated and productive. Several tracts containing good farms might be referred to, such as Heron Island, Maguasha, New Richmond, Capelin, Bonaventure, New Carlisle and Shigawake.

KIND OF SOIL OVERLYING MIDDLE CARBONIFEROUS ROCKS.

Kind of soil upon Middle Carboniferous rocks.

Rocks of this age underlie that part of the district east of Salmon Beach, Gloucester county. The surface here is also flat, and the general aspect of the country tame and monotonous, relieved, however, to some extent, by the bold cliffs which face the Baie des Chaleurs at New Bandon and Pokeshaw. At Salmon Beach, the soil is clayey, being composed of till underneath, with a few inches of Leda clay over it. To the east of this, it is more gravelly or sandy as far as Grand Anse, where it again becomes partly of a clayey nature. This latter character prevalls, indeed, in many of the lower tracts bordering the Bay and Gnlf, and especially in river valleys. In these, however, the soil is more or less loamy.

In the districts occupied with clay deposits, the soil is generally more or less impervious to water, and being flat, like that underlaid by Lower Carboniferous rocks, is also liable to be wet in spring, and during rainy seasons. It is nevertheless excellent for hay and cereals, and when lime in sufficient quantities is applied, is highly productive. The arenaceous tracts, on the contrary, constitute rather dry and hungry soils. Lime is the great *desideratum* for these, but more especially for the clayey lands.

Good quality of land in eastern Gloucester.

A large part of eastern Gloucester is occupied with good arable land, which only requires proper cultivation to render it a desirable farming locality. At present, fishing and other occupations interfere, to some extent, with successful agricultural pursuits. The construction of the Caraquette Railway through it must enhance the value of land, however, affording, as it does, increased facilities of transport for agricultural produce, freestone, fish, etc., so abundant here.

SOILS UPON CAMBRO-SILURIAN AND PRE-CAMBRIAN ROCKS.

Character of soil resting upon Cambro-Silurian and Pre-Cambrian.

The character of the soil resting upon the Cambro-Silurian in Gloucester county was described in some detail in the preliminary report, 1885, and nothing further can be added respecting it. In general, it may be stated, the surface is boulder-strewn, and rock bosses are not infrequent; nevertheless, when cleared, the soil is found in many places to be deep and rich. At Point Maquereau, and behind Port Daniel, the tract occupied by these and the Pre-Cambrian rocks is more elevated and rugged, and plentifully covered with boulders. Here, however, it is almost entirely unsettled.

In regard to the districts underlaid by Pre-Cambrian rocks alone at Tetê-à-gauche and Jacquet rivers, and at Point Macquereau, occupying as they do only limited areas, it does not seem necessary to refer to them in detail. Wherever surface deposits are seen as solely, or in any

considerable part belonging to them, they form a poor, stony soil. These rocks, have, however, furnished large quantities of boulders and coarse material to the soils of contiguous districts.

The trees found growing upon the areas underlaid by the Carboniferous and other rocks are much the same in regard to species and dimensions as those already enumerated as occurring on the Silurian, although somewhat different in their numerical relation. On the Carboniferous, however, we find in addition, the hemlock (*Tsuga Canadensis*) 1½ to 2½ feet in thickness above the roots; black spruce (*Picea nigra*), a larger tree, 1 to 2½ feet in thickness, and the scrub pine (*Pinus Banksiana*), a small tree, found on gravelly and sandy soils. The sweet fern (*Myrica asplenifolia*) is met with here only on the dry soil of the Carboniferous rocks. **Trees upon Carboniferous area.**

FAUNA.

From the fact that the chief part of the area under review is still covered by forests, it may be inferred that animals, of which they form the habitat, are more numerous here than in the southern counties of New Brunswick, and such, in the course of exploration, was found to be the case. The moose (*Alce Americanus*), caribou, (*Rangifer caribou*), the bear (*Ursus Americanus*), lynx (*Lynx Canadensis*), fox (*Vulpes vulgaris*), and the fur-bearing species, such as the beaver, (*Castor fiber*), otter, (*Lutra Canadensis*), pine marten, or sable, (*Mustela Americana*), the fisher, or black cat, (*M. Pennantii*), and the weasels (*Putorius vulgaris*), and *P. ermineus*, the mink (*P. vison*), the skunk, (*Mephitis mephitica*), the little brown bat, (*Vespertilio subulatus*), the common mole, (*Scalops aquaticus*), flying squirrel (*Sciuropterus volucella*), the common red squirrel, (*Sciurus hudsonius*), meadow mouse, (*Arvicola riparius*), musk rat, (*Fiber zibethicus*), porcupine, (*Erethizon dorsatus*), and hare, (*Lepus Americanus*), are found in greater or less numbers. The Restigouche and its tributaries are favourite hunting grounds. **Fauna.** **Animals inhabiting the forests.**

The birds which frequent the province of New Brunswick are now being industriously studied by Mr. M. Chamberlain, of St. John, and other members of the Natural History Society, and a catalogue has been published (see Bulletin of the Natural History Society of N.B. Nos. I and II.)

The common crow (*Corvus frugivorus*), the robin, (*Merula migratoria*), besides the snow-birds usually observed, were seen in this district by the writer during the winter of 1885-86. The loon (*Colymbus torquatus*) frequents the open portions of the Baie des Chaleurs all winter. **Birds.**

Fish of many different kinds are proverbially abundant in the Baie des Chaleurs; and the Restigouche, Nepisiguit, Cascapedia, etc., are **Fish.**

Salmon and trout.

famous for salmon and trout. The smelt, (*Osmerus mordax*), which is also anadromous, goes up these waters at certain seasons, and great quantities are caught; indeed, smelt fishing has become an important industry of late years in the northern counties of New Brunswick during winter. Whitefish (*Coregonus albus*) are occasionally seen in some of the upper branches of the Restigouche, but they are scarce. The common eel (*Anguilla rostrata*), is speared in great numbers in the muddy estuaries.

Fish in Baie des Chaleurs.

The fish most abundant in the Baie des Chaleurs are well known, and need not be enumerated. The cod, mackerel, herring and capelin, the latter caught in great quantities along sand beaches and dunes with scoop-nets, and used for manuring the land, occur in great profusion, and often swarm in its waters; while others, such as the halibut (*Hippoglossus vulgaris*), the flounder, tom-cod, sculpin, etc., are also frequently caught. The basking shark, white whale, (*Delphinapterus catodon*) and the seal (*Phoca vitulina*) are rarely seen.

Crustaceans.

Of crustaceans, the lobster (*Homarus Americanus*) abounds all around the coasts. Of late years, however, owing to the great numbers caught, it has become considerably depleted, and fishermen report it as much smaller than formerly. The crab (*Cancer irroratus*) is plentiful, and the squid (*Ommatostrephes illecebrosa*) is sometimes thrown up on the shores of the south side of the Baie des Chaleurs; while the barnacle (*Balanus balanoides?*) is found adhering to the rocks, etc., everywhere in littoral waters.

Molluscan fauna.

The Baie des Chaleurs also supports an abundant molluscan fauna, closely similar to that which inhabits the southern part of the Gulf of St. Lawrence, where dredgings were made by Mr. Whiteaves some years ago.

Materials of Economic Importance in the Surface Deposits.

Materials of economic importance in the surface deposits.

The only materials of economic importance known to occur in the surface deposits of this disrrict are those which have been cursorily referred to in previous pages, viz.: brick clays, shell marl and peat. Along with these may, perhaps, be classed fine sand, used in the manufacture of bricks and mortar, and gravels of different kinds suitable for road-making, ballasting railways, etc.

Brick-clay.

Brick-clay is found in the Leda clay beds in numerous localities around the Baie des Chaleurs; and also of fluviatile formation in river valleys in the interior. The manufacture of bricks is, however, carried on here merely to supply the local demand, which is not great. At Bathurst, a brick-kiln has been in operation for some years, and one was also started at Campbellton, but work in the latter place has recently been discontinued.

Brick-kilns.

Shell marl has been mentioned as occurring at Belledune, Charlo and New Richmond; and I am informed it is also found in one of the small lakes behind the town of New Carlisle. It is used to a limited extent for fertilizing purposes and is said to be excellent for the heavier clay soils overlying the Lower and Middle Carboniferous tracts skirting the Baie des Chaleurs. **Shell marls, where found.**

Peat is found in numerous places, nearly all of which are enumerated on pages 29 and 30 M (this report). It has not yet, however, been utilized in any way in this district. **Peat.**

Sands and gravels occur in ridges, terraces and beaches, and as already stated, are everywhere abundant. Fine blown sand, of use for the purposes above mentioned, can be found at numerous points around the Baie des Chaleurs, especially in the modern beaches, being developed in great masses at Eel River, Alston and Carron Points at Bathurst, Blue Cove and Point Mizzenette, Pokemouche, etc. It also occurs in the Saxicava sand deposits in various places. Gravel, suitable for the purposes above referred to, is found also in the Saxicava sand beds, particularly at Bathurst, Tête-à-gauche, New Mills, Christopher's Brook, etc. Pits (from which large quantities were taken) were opened in these and other localities during the construction of the Intercolonial railway. **Sands and gravels.**

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON

EXPLORATIONS

IN PORTIONS OF THE COUNTIES OF

VICTORIA, NORTHUMBERLAND AND RESTIGOUCHE,

NEW BRUNSWICK.

TO ACCOMPANY QUARTER SHEET MAP 2. N.W.

BY

L. W. BAILEY, M.A., Ph.D., F.R.S.C.,
PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF NEW BRUNSWICK,

AND

W. McINNES.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.

1887.

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S.

Director of the Geological and Natural History Survey of Canada.

SIR,—The following report, which we have the honour to submit, embraces the results of observations and explorations made by us, with the assistance of Mr. J. H. Bailey, during the summers of 1885 and 1886, in northern New Brunswick.

The object of these explorations was twofold, viz, first, to obtain the necessary data for the completion of the quarter-sheet map of the series of New Brunswick maps, No. 2. N.W., which accompanies this report, and, secondly, the determination of the succession of the Silurian strata in the northern portion of the province, and their relations to other systems. As the investigations in the latter direction embrace areas beyond the limits of the map, and are not yet completed, the present report will be confined to the region which is now delineated, embracing portions of Victoria, Madawaska, Northumberland and Restigouche counties.

The courses and dips, both in the report and on the map, are given with reference to the true meridian, the variation being about 20°-21° west.

Our thanks are again due to the Manager of the New Brunswick Railway for free passes, and other facilities, on the several lines under his direction.

We have the honour to be,

Sir,

Your obedient servants,

L. W. BAILEY.
WM. McINNES.

October, 1887.

REPORT

ON

EXPLORATIONS

IN

PORTIONS OF THE COUNTIES OF

VICTORIA, NORTHUMBERLAND AND RESTIGOUCHE, NEW BRUNSWICK.

The area to which this report and the accompanying map refer, lies immediately north of that mapped and reported on in 1885; while upon the eastern and western sides it is bounded by the areas previously surveyed and mapped by Mr. R. W. Ells in the counties of Northumberland, Gloucester and Restigouche. On the west it is in part bordered by the state of Maine, and in part by that portion of New Brunswick which, above the Grand Falls of the St. John River, extends westerly between the last named state and the province of Quebec. It may be added that this latter tract, together with a small triangular area lying between the headwaters of the Green and Quatawamkedgewick rivers, in the county of Restigouche, embraces the only portions of New Brunswick which remain to be surveyed. Region described.

The formations represented within the area to be considered are, in descending order, as follows:— Formations.

G. 1. Lower Carboniferous.
F. Devonian.
E. Silurian.
D. Cambro-Silurian.
A. B. Pre-Cambrian.
Gr. Granite and related rocks.

G. 1. Lower Carboniferous.

Within the district examined, the Lower Carboniferous rocks are confined to the valley of the Tobique. They are the northern half of the outlier described in part G. of the Annual Report for 1885, and as they have been already pretty well considered in previous years, little need be said of them here.

Extent of area. The greatest breadth of the outlier is about twelve miles, and it extends northerly on the Tobique to a point a little beyond Blue Mountain bend. The strata are lying everywhere nearly horizontally, with broad, low undulations shewing that they have been subjected to but little disturbance since their original deposition. Their succession on the Tobique, in descending order, seems to be :—

Succession of beds.

Coarse, red conglomerate.
Gypsum.
Soft, red, shaly sandstone, with thin bands of limestone.
Limestone.
Highly calcareous white and red sandstone.
Red and grey grits and conglomerates.
Soft red shales.
Red sandstones and conglomerates.

Volcanic rocks. At the edge of the basin on Otelloch stream, and at the Blue Mountains, small masses of volcanic origin occur. These consist of ash-like felsitic beds, volcanic agglomerates, traps and claystone porphyries, and are probably contemporaneous with the upper beds of the Lower Carboniferous.

Trap. Just above the Blue Mountains, these beds are represented by a massive ledge of green, chloritic, highly calcareous, amygdaloidal trap, which is exposed on the left bank of the stream; in general aspect, this trap closely resembles those of Lower Carboniferous age in the southern part of the province. A flesh pink mineral, resembling natrolite, occurs in this ledge, but the vesicles are mostly filled with calcite.

Blue Mountains. The principle exposure of the volcanic material, however, is that making up the mass of the Blue Mountains and rising in low cliffs from the water's edge at the bend of the river. These are red crystalline felsites, hardly distinguishable from those of Pre-Cambrian age, and dull reddish-purple, banded, felsitic beds of ash-like aspect, associated with volcanic breccia or agglomerate, with light-green, hard, serpentinous matrix. Where exposed on the steep sides of the upper peak, they show an almost horizontal, gently undulating stratification. None of these beds are seen in actual contact with the Lower Carboniferous, so that stratigraphical evidence of their relative age is wanting.

Their close similarity to the volcanic masses so common in other parts of the province at the base of the Millstone Grit, warrants the conjecture that these are also overflows which have occurred about that time. Limestones of Lower Carboniferous age, occurring about half a mile below these beds on the river, are quite hard and crystalline, but show no disturbance. Red and greenish-grey in colour, often

Limestones.

prettily marbled, and hard enough to take a good polish, these limestones would probably afford handsome marbles for ornamental purposes.

On the Otelloch, claystone porphyry is associated with the Lower Carboniferous sandstones, and soft, green and purple slates, of supposed Silurian age, are cut and overlaid by a trap similar to that first above described. The purple colour of these slates is often superficial, and is probably only a local discolouration, caused by the red sandstones which have overlaid them.

At the confluence of the Wapskehegan with the Tobique, on the left bank of the latter stream, twenty-three miles by road from the St. John River, and again two miles further up, high cliffs of gypsum are seen. These beds form the sides of a very slight undulation, dipping easterly at a low angle, the top of which, where it approaches the river, has been denuded, leaving only the underlying shales and limestones exposed. At the upper of these two exposures, locally known as Plaster Rock, the cliff rises vertically from the water's edge to a height of 150 feet; it is made up of beds of impure gypsum of different colours, varying from dull purplish-red to greenish-white, with thin layers, which are pure white and fibrous; it is underlaid by soft, red shales, with thin bands of limestone, and by massive beds of siliceous limestone. Ascending Salt Creek (so called from its slightly saline taste), which empties into the Tobique just above the cliff, the gypsum is seen at intervals, cropping out from the sides of the ravine worn by the brook, for a distance of a mile back from the river. East of this, no exposures are seen, the surface being hidden by a thick covering of drift, until the elevation known as Plaster Rock ridge is reached. This ridge, lying two miles back from the river, is four hundred feet above it, and forms a high, level, table land, clothed with a large growth of hardwood, and with a soil apparently well adapted for cultivation. Outcrops of coarse, red conglomerate, in heavy beds, lying almost horizontal, shew near the top of the slope. They would thus overlie the gypsum and form the summit of the Lower Carboniferous, on the Tobique. The gradually rising ground, lying between the Tobique River and the foot of the ridge, is pitted with a number of the large funnel-shaped pot-holes so common in districts underlaid by gypsum. Some of those holes are upwards of fifty feet in depth, with steeply sloping sides, and with a width at the top of about sixty feet. Gypsum.

Without attempting to calculate the amount of gypsum contained in these beds, it will be readily inferred, from the above considerations, that the quantity is very large—certainly many million tons.

Tufaceous limestone.

A rather remarkable outcrop of tufaceous limestone in thick beds, which seem to be a continuation of those underlying the gypsum, occurs in the bank just above the plaster cliff. This has been described by Mr. Hind in his "Preliminary Report on the Geology of New Brunswick," page 64.

Character of soil.

This Lower Carboniferous tract, as well as the Silurian area succeeding it on the river, is generally characterized by highly productive soils, well adapted for cultivation. Extensive intervales and large flat islands occur in many places along the river as far as the main forks. Part of this low land is covered with groves of large elm and balsam-poplar; most of the lots adjacent to the river, however, are taken up, and settlement has already extended to within half a mile of the forks, or for fifty-four miles back from the St. John River. A projected railroad, connecting with the New Brunswick railway system at the mouth of the Tobique, and extending up the river as far as Plaster Rock, will, when built, add materially to the value of this section.

F. Devonian.

Devonian on Campbell River.

A small area of soft, dark blue, calcareous slates and soft, dark-grey, rusty-buff weathering sandstones referable to this age occurs on Campbell River, extending for a mile or more above the mouth of the Don, and for about three miles below this point. The dip, as seen at a small island a mile and a half below the mouth of the Don, is S. 45° E. $<$ 75°, and two miles below S. 80° W. $<$ 70°.

The exposures are too few, and the strata too much crumpled, to allow of their structure being definitely ascertained, but they probably form an irregular synclinal lying in a trough in the older rocks, which has been protected by them from denudation. The few exposures seen are abundantly fossiliferous, although, owing to the cleavage which cuts the bedding obliquely, the forms obtained were generally imperfect and distorted. Those collected, however, which have been determined by Mr. Ami, justify the beds being placed in the Oriskany group, at the base of the Devonian. From a small collection made at the locality, Mr. Ami has furnished the following list:—

Devonian fossils.

1. The carbonized stem of some plant too imperfect for identification.
2. *Polypora*. Sp. indt. (Generic reference doubtful.)
3. *Strophomena* (*Strophodonta*) *magnifica*, Hall. Several casts of the interior of this shell present the muscular impressions very perfect.
4. *Strophomena* (*Strophodonta*) *varistriata*? Conrad. A form which is most probably referable to the above species occurs in the collection.
5. *Strophomena rhomboidalis*, Wilckens. There are numerous examples of this species occurring at this locality, and they appear to be that

form or variety described and figured by Prof. Hall as the *S. rugosa* (Palæontology of New York, Vol. III.)

6. *Orthis hipparionyx*, Vanuxm. Amongst the species collected are two or three casts of the ventral or flat valve of the above *Orthis*, showing the imprints of the muscular adductors and their bilobate character very well.

7. *Orthis*. Sp. indt. (Of the type of *O. oblata*. H)

8. *Leptocœlia flabellites*, Conrad. Small examples of a species of *Leptocœlia*, which cannot be differentiated from the above, occur in the collection. They resemble those from Gaspé in a very marked degree.

9. *Eatonia ?* (Portion of the cast of the ventral valve of a species of *Eatonia*, too imperfect, however, for specific identification.

10. *Spirifera arrecta*, Hall. Numerous internal casts of this well-known and easily recognized species occur at this locality, and present all the characters and variations described by Prof. Hall in Pal. N. Y., Vol. III., p. 422.

11. *Spirifera*. Sp. indt. Besides the casts of *S. arrecta*, H., above referred to, there occur internal casts of another species of *Spirifera*, much longer, proportionally, and with elevated umbonal region. They present many points in common with *S. submucronata*, H., and with *S. cycloptera*, H., also.

12. *Pterinea textilis*, H. (or a very closely allied species).

13. *Pterinea*, or *Megambonia*. (Probably a species of the latter, and as yet undescribed.)

14. Pygidium of a trilobite resembling *Calymene*.

Of the above species, Nos. 1, 3, 5, 6, 8, 9, 10 and 12 are known from the Oriskany. For those who consider the Oriskany as forming part of the Silurian the above would then be referable to that system.

E. Silurian.

The rocks of this system, within the district described, cover a very large area, embracing fully one half of the quarter sheet map, or all that portion of the latter which lies north-west of a nearly uniform but slightly crescentic line, extending from the head of the Three Brooks, on the Tobique River, to the valley of the Upsalquitch. To the north and west, the formation passes beyond the limits of the map. Extent of area.

The surface features of this Silurian tract have been pretty fully described in previous reports, and especially in those of Mr. Robert Chalmers, on the Superficial Geology of New Brunswick.* A few additional facts may, however, be stated here. Over almost the entire district, the country is hilly and the scenery picturesque, but few of the hills reach an altitude of one thousand feet, while their slopes, though occasionally abrupt, are in general sufficiently moderate to ad- Surface features.

* Report of Progress, 1882-3-4, and Annual Report, 1885, Part G G.

mit of successful agricultural operations. Most of the eminences have the form of long, narrow ridges, or that of inverted canoes, with a regular and continuous crest line, but at times, this is replaced by a more or less serrated outline, or, more rarely, where igneous rocks occur, by conical or pyramidal forms.

Watershed. The district is everywhere well watered, including upon the southern side, in addition to a small part of the St. John, a considerable portion of the Tobique River and some of its most important affluents, upon the west, the Salmon River, Little River and Grand River, tributary to the St. John, and upon the north, the more southerly branches of the Restigouche and Upsalquitch. The position and relations of these streams would seem to indicate the existence of a definite watershed extending north-easterly from the St. John River near the Grand Falls to and beyond the headwaters of the Upsalquitch, and parallel, or nearly so, to the course of the southern margin of the Silurian tract. By its tributary, the Wagan, the Restigouche approaches quite nearly to the head of Grand River, connected with the St. John, and the short portage between the two has long been used as an easy means of passage from one set of waters to the other. The Tobique again is readily navigable by canoes, through the Little Tobique, to its source in Nictor Lake, and this is separated by another short portage from the head of the Nepisiquit. Owing to the facilities of communication thus offered, the fine scenery which their streams afford, and the fact that, as a rule, they abound with fish, they furnish many attractions to tourists and sportsmen, while through the sale of the fishing privileges, they are becoming an increasing source of provincial revenue. They are also the seat of extensive lumbering operations.

"Fertile belt." The general fertility of the Silurian district has been a frequent subject of comment, and certain portions of it, more particularly in Carleton county and in Aroostook county, Maine, are quite famed, both for the vigor of their forest growth and for their agricultural capabilities. Prof. G. L. Goodale, in the seventh report on the agriculture of Maine, commenting on this feature, and after alluding to the species of plants by which the county of Aroostook is characterized, divides it into two portions, both adjoining New Brunswick, but of which one, bordering the Aroostook River and lying to the south of Grand Falls, is much more fertile than the other, and embraces many species which are usually to be met with only in a more southern latitude. He finds this difference also to be coincident approximately with the character of the rocks in the tracts, that of the more southerly or "fertile belt" being especially marked by the presence of calcareous strata. If this be the true cause of the difference it may be expected that similar results would be observed where these several

groups of rocks, in their eastward extension, enter the limits of the province. And this would to some extent appear to be the case. Here, also, a "fertile belt," continuous with that of Aroostook, is well marked, and is rapidly becoming the seat of thriving settlements, but owing to a change in the course of the strata in passing from Maine to New Brunswick, the width of the belt in the latter is considerably increased, extending probably at least as far north as Edmunston, and eastward to the valley of the Restigouche. Even above Edmunston, much good land is to be found, but the more hilly character of the country in this direction, combined with the shortness of the season and the occurrence of early frosts, give here a less promising aspect to the work of the agriculturist.

Geological features.

The geological features of the district under review present but little diversity, being very similar to those of the Silurian tracts described in previous reports. The prevailing rocks are slates, mostly of dark grey colours, weathering to bluish-grey and often conspicuously banded, but in places they are greenish or reddish. They are very generally calcareous and at times markedly so, but bands of true limestone are infrequent. The slates not uncommonly alternate with sandstones, which are also calcareous, but beds of coarser character are rarely met with. Intrusive rocks are also not common, though covering some considerable areas.

Disturbance.

The attitude of the beds over the Silurian tract is usually one indicative of great disturbance, and over large areas, great masses of strata have been affected by extensive and complicated folds. But over other considerable areas, it would seem that the pressure to which the beds have been subjected has resulted only in local crumplings, the beds as a whole still occupying positions which are not far from horizontal. It is in this way that they are made to spread so widely and to acquire the appearance of having a much greater thickness than they actually possess. In connection with these movements, slaty cleavage has been very strongly developed, and in many instances makes the recognition of the true stratification a matter of some difficulty. Owing to the circumstances to which reference has been made, together with the paucity of fossils, any attempts to determine the relative position of the different groups of strata, their thickness or their correlation with those of other regions, are at once inconclusive and unsatisfactory. Indeed within the limits to which the present report relates, there are very few facts which help to throw much light upon questions of this character. So far as at present known, these relations seem most likely to be disclosed by the study of the regions to the north and west of that here described, more particularly those of the Aroostook region in the state of Maine and the Temiscouata re-

Slaty cleavage.

gion in Quebec, but as these are still under examination, any further reference to the conclusions which they indicate would be premature. It will here be sufficient to say that of the fossils collected within the area under discussion, all are distinctly Silurian, indicating in most instances an horizon about that of the Lower Helderberg formation.

Fossils.

D. Cambro-Silurian.

The belt of rocks which has been classed in the accompanying map as Cambro-Silurian, is a continuation of the strata of that supposed age described in the report of last year as forming a rim protruding from underneath the eastern edge of the Silurian area in the district immediately to the south.

In the absence of any contained fossils, these sediments have been so placed on account of their stratigraphical position, under the Silurian, and on account of their close lithological resemblance to measures which have been referred to this age further to the south.

Typical rocks.

As seen on Campbell and Galquac rivers, and at several intervening points, they consist of thick beds of felspathic sandstones and quartzites, with layers of hard, blue slate interstratified. They show evidence of having been crumpled everywhere into sharp folds, the tops of which have been denuded, and the strata now stand on end or are tilted at very high angles; they preserve a tolerably uniform strike, however, of about N. 40° E.

Conglomerate.

A persistent band of hard conglomerate, holding pebbles of white quartz, quartzite, jasper and black slate, occurs near the edge of this belt all along; it is seen in both the Galquac and Wapskehegan rivers, and Mr. Hind has noted the occurrence of large blocks of a similar conglomerate on Campbell River, about two miles above its junction with the Serpentine.

Although resembling in many respects the conglomerates occurring in the Silurian, the absence of any of the beds which are everywhere associated with the Silurian conglomerate, and its stratigraphical position (dip N. 55° W. $<$ 75° to 90′), render it probable that it is here a basal conglomerate of the Cambro-Silurian, holding pebbles which have been derived from some Cambrian or Pre-Cambrian rocks which have not yet been noted.

General Remarks on the Pre-Cambrian Area.

General elevation.

The region within the limits of the present sheet, lying to the southeast of the great Silurian area, is everywhere of a very rugged and mountainous character. Its general height above the sea, as ascer-

tained by barometer levels, is over 1,200 feet, and throughout the whole district, in every direction, peaks rise above this general level to a height of 2,000 to 2,700 feet. Among the more prominent of these, of which the heights are known, are Bald Mountain, near the head waters of the south branch of Nipisiguit River, about 2,500 feet above the sea; Sagamook or Bald Mountain, rising abruptly from the southern shore of Nictor Lake, 2,537 feet; Bald Mountain, about three miles above Indian Falls, on the right bank of the Nepisiguit river, 1,922 feet; Bald Head, six miles back from the Tobique, at Riley Brook, a very symmetrical, conical peak, rising to a height of about 1,900 feet, and the Blue Mountains, upper and lower, coming close to the left bank of the Tobique, thirteen miles below the forks, about 1,724 feet. Height of peaks.

From these central highlands flow off to the sea rivers, which empty into the Bay of Chaleur on the north-east, into the Straits of Northumberland on the east, and into the Bay of Fundy on the south. Owing to the great height of this central watershed, these streams are all very rapid and difficult of navigation, flowing through deep, narrow valleys, with often high, precipitous banks. As an example of their rapidity of descent, the right hand branch of the Tobique may be taken. From the lake at its source to the main forks, a distance of twenty-seven miles, it has a fall of about 780 feet, or an average descent of a little over twenty-five feet to the mile. Early in the season, before the water has fallen to its summer level, most of these streams may be traversed with light birch bark canoes, by making portages around falls and rapids, and shoeing the canoes with cedar splints in the rougher stretches. Brook trout abound in all the waters, and salmon ascend many of the streams. On the Tobique, the salmon now afford good fly-fishing, although up to quite recently, it was generally believed that they would not rise to a fly. White-fish, *Coregonus albus*, are also plentiful in the Tobique, and in the lakes at the head of the right hand branch Togue, *Salvelinus Namaycush*, are caught in large numbers through the ice in the winter. Eels are common in the lakes, and lampreys in the streams draining them, where they were observed about the end of June, making their spawning beds in rapid parts of the stream, by dragging away the stones and pebbles from one place and dropping them just below, forming a hollow about eighteen inches in depth, with corresponding mound of pebbles below. Central watershed. Rate of descent. Fishes.

Animals, useful for food or valuable on account of their skins, are fairly plentiful in parts of this region. Moose and cariboo are found in considerable numbers, and black bear, beaver, otter, lynx, marten and mink, are trapped quite extensively by the Indians and by white hunters; of these fur-bearing animals, the otter and beaver are fast Game.

Timber.

becoming rare and, at the present rate of destruction, will in a very few years be almost extinct in the district. Large areas are still covered with a thick growth of black spruce of fair size, and in this lumber the chief value of the tract lies; the pine has been exhausted for many years, only a few scattering specimens of white pine and sapling red pine are now to be seen. Cedar of good size is plentiful along most of the water courses, and hardwood trees, of different varieties, maple, birch, ash, &c., are almost everywhere intermixed with the spruce. The rocky character of the surface, covered over large areas with boulders of granite, gneiss and quartzite, derived for the most part from the underlying rocks, and its extreme roughness render it generally quite unsuited for cultivation and dependant for future value on its forest growth.

A.B. Pre-Cambrian.

Geological boundaries.

A large part of the area under consideration is occupied by rocks supposed to be of this age. Their occurrence on the Nepisiguit River and on the streams flowing into the Miramichi has been already referred to by Dr. Ells in the Report of Progress for 1879-80, pages 30 and 31 D, and the geological boundaries in this part of the region are laid down from his work. North of the Nepisiguit River, the western edge of these rocks is defined by the unconformable overlap of the Silurian slates, which here extend eastward to a point about midway between the head and foot of Nictor Lake; further south, a band of slates and hard sandstones, apparently more recent than the Pre-Cambrian, and overlying them, lies between them and the Silurian. These are thought to be of Cambro-Silurian age.

Typical rocks.

The typical rocks of this formation, as seen in its south-eastern extension, consist of very hard crystalline felsites, generally of a red colour, highly chloritic quartzites and felspathic and micaceous schists. The stratification of these beds is generally very obscure and difficult to ascertain with certainty; their general strike, as nearly as it could be obtained, is N. 70° E. Owing to the densely wooded nature of the country and the absence of rock exposures *in situ* over large areas, the structure can only with difficulty be worked out, and on the accompanying map, an attempt has only been made to fix, with an approach to accuracy, the boundaries of the formation. It is cut by large areas of intruded granite, which will be referred to later on under that head.

Succession on Campbell River.

Ascending the right hand branch of the Tobique, the first rocks supposed of this to be age are seen just below Sixteen-mile Brook, or about four miles above the mouth of the Serpentine; these are massive ledges of greenish-grey crystalline felsite mottled with red blotches,

without apparent dip. This exposure seems to mark the western edge of the Pre-Cambrian on the Tobique, as just above, where the stream bends to the west, are seen hard felspathic sandstones and blue slates, belonging apparently to the overlying Cambro-Silurian; these extend for about a mile beyond, or until they again are overlaid by the soft, calcareous beds of the Oriskany basin, elsewhere described. Above these last named beds, for some distance, no exposures are met with; the soil is, however, filled with angular blocks of a coarse amygdaloidal diorite, which occurs in place about two miles above the mouth of the Don. Hard, crystalline, red and greenish-grey felsites follow, and. with occasional ledges of fine-grained syenite with specks of clear quartz and red felspar—the grains of quartz sometimes circled with felspar—and of amygdaloidal diorite, continue to the foot of Tobique Lake. Although obscure, the strike, where recognized, seemed to be about east and west. Along Tobique Lake no exposures are seen, but the shores are plentifully strewn with blocks and boulders of fine red syenite and greenish-grey chloritic syenite. The immediate shores of the lake are low and densely wooded with black spruce to the water's edge, giving the lake a dark and gloomy appearance. A ledge of felspathic schist, with a strike N.E., is mentioned by Mr. Hind as occurring on the shore of Milpagus Lake, which lies about a mile to the south-east of the head of Tobique Lake. About two miles east of this lake is Long Lake, a fine sheet of water five miles and a half in length, with an average width of about half a mile; although showing no ledges *in situ*, the same boulders are common along its shores to a point about midway up the lake, beyond which granite only is seen. Ledges of coarse, green, chloritic diabase and hard, green chloritic quartzite, with veins of quartz and quite micaceous and schistose in certain layers, occur on the portage to Serpentine Lake, which lies four miles to the north-east, and form the hills separating Portage from Adder Lake. The immediate shores of Serpentine Lake are quite low and flat, and but one exposure was seen; this occurs on a tongue of land jutting out into the lake from its western side, and is a hard, felspathic schist, striking about N. 70° E., and dipping to the north at an angle of 65°. On Serpentine River, between the lake and the stillwater, boulders of pale reddish crystalline felsite and syenite are common, and the former is present in place at the head of the dead water. From this point down to the edge of the Cambro-Silurian belt, the rocks are hard, grey quartzites and schists, highly chloritic, and often with many thin veins of quartz running parallel with the planes of cleavage. About eight miles above the forks there is a ridge of coarse gneissic granite, which seems to cut these beds—possibly a spur from the main granitic mass to the

Tobique Lake.

Milpagus Lake.

Long Lake.

Serpentine Lake.

Serpentine River.

east; this will be further referred to. East of the main body of granite, the Pre-Cambrian rocks consist mainly of felspathic gneisses and schists; they are described by Mr. Ells in the Report of Progress for 1879-80, page 32 D.

Blue Mountains. In addition to the main area of these rocks above described, another smaller tract lying to the southeast of the Blue Mountains is occupied by strata, which are probably also of Pre-Cambrian age. Very hard white and red crystalline felsites, not distinguishable in macroscopical character from those so common in the main Pre-Cambrian area, form high cliffs on the Gulquac River, a few miles up from its mouth. Although not occurring in actual contact with the Lower Carboniferous strata, they are seen for a considerable distance along the stream, rising in high bluffs on the right bank, while on the left, the red sandstones and conglomerates of the Lower Carboniferous lie in their usual, almost horizontal, position, and show neither alteration nor disturbance, both of which might be looked for were these felsites intruded since the deposition of the sandstones.

Gr. Granite.

Two areas. Two areas of granite come within the district under consideration. The larger of these has an average width of about twelve miles, and extends from the head waters of the NW.. Miramichi in a south-westerly direction to and beyond the lakes at the sources of the Gulquac and Little S.W. Miramichi rivers. The smaller is a long narrow tongue, about four miles in width, running up into the Pre-Cambrian from the main granitic mass to the south. It lies about five miles to the east of the first and nearly parallel to it.

Character of the granite. The granite in both of these areas is of the same character and is quite similar to that described in previous reports as intrusive and probably of Devonian age; in texture, it varies from medium grain to coarse, with large crystals of orthoclase felspar. The mica is often a black variety of this mineral, and is not unfrequently replaced by hornblende; sometimes both mica and hornblende are present. In the absence of exposures of rock *in situ*, the south-westward edge of the larger granitic mass has been fixed at the western limit of the large granite blocks and boulders which are strewn along the shores and neighbouring hill-sides about the upper half of Long Lake. The difference in the character of the boulders along the upper and lower stretches of this lake is strongly marked; along the lower part of the lake, chloritic quartzites, gneisses and schists form the larger number of the boulders, and large blocks of granite are markedly absent, while towards its head, those of granite are the prevailing feature and the others are seldom seen.

Boulders.

Granite on Serpentine River.

In addition to the areas already referred to, a ridge of gneissic granite, about a quarter of a mile in width, trending W.N.W., crosses Serpentine River midway between the lake and its junction with Campbell River, forming a series of rapids and falls. The granite composing this ridge differs very materially in structure from that described above; it is of a coarse, grey variety, with black mica, and generally with a distinctly gneissic arrangement of its constituents and is in places traversed by ramifying veins of semi-vitreous, rusty-weathering quartz. Owing to the generally contorted and highly altered aspect of the Pre-Cambrian, evidence of the intrusion of the granite in the altering and crumpling of the beds* is not readily recognized. Both of these results of intrusion, however, are here present, though to a limited degree; as the granite is approached on either side, the quartzites become hard, quartzose schists, cut in every direction by numerous veins of quartz, and noticeably more twisted and distorted. Although it cannot be stated with any certainty that these gneissic granites may not form a part of the system of rocks which encloses them, yet it would require a more detailed examination to settle the point, and they are provisionally classed on the accompanying map with the intruded granites. In last year's report, Part G., mention was made of a very similar mass of granite which forms the high hill at the forks of the South-West Miramichi River in Carleton county; this was also provisionally placed with the intruded granite.

Character of the surface.

What has been said of the shores about the head of Long Lake will apply equally to the whole region about the head waters of the Gulquac, and to the watershed between these waters and the Little South-West Miramichi. Nowhere were any ledges seen, and everywhere the surface was strewn with large granite boulders. On the Little South-West Miramichi, however, ledges of grey granite occur and the eastern edge of the main granitic mass, as well as the limits of the smaller belt are here clearly seen. In both cases they are cutting Pre-Cambrian gnessis and schists.†

MATERIALS OF ECONOMIC IMPORTANCE.

Although the district under consideration, as far as it has been examined, has not proved very rich in economic minerals, yet it contains some which are worthy of mention. That valuable minerals, other than those enumerated, may exist in the district is, of course, possible and even probable. A thorough prospecting exploration of the whole

* This cannot by itself be taken as evidence of intrusion—it can be readily otherwise explained—nor does it even always accompany intrusion.—A. R. C. S.

† Report of Progress, 1879-80, page 32, D.

region, with the time and means at our disposal, has been impossible; in the unsettled portions—and these embrace fully three-fourths of its entire extent—no examination, which can claim to have been at all an exhaustive one, has been made. The principal streams have been examined and to some extent the country bordering them, and a number of traverses made from point to point through the forest-covered areas. These have afforded the means of obtaining a good knowledge of the general geology of the region and have enabled us to lay down, we hope with a fair approach to accuracy, the boundaries of the different geological systems; they have not resulted, however, in the discovery of any minerals of economic importance, although the highly altered character of the strata over large areas and the numerous intrusions and contacts would seem favourable to the formation of mineral-bearing veins.

The following are the more important minerals known to occur in the district:—

Gypsum.—Large beds of this mineral occur on the left bank of the Tobique River just above the mouth of its affluent the Wapskehegan, or about thirty miles from the St. John. Their mode of occurrence and some idea of the probable extent of the deposits has been given in preceding pages. The occurrence of these beds and their value to the agriculturist was early pointed out, and the neighbouring farmers have used the gypsum as a fertilizer to a greater or less extent ever since the country has been settled.

In more recent years it has become, to a limited degree, an article of commerce, although distance from a market and the rude means of transport available have prevented its extended use. It has been shipped either by carrying it down the river during high water on rafts or by hauling on the ice in the winter time. Considerable quantities have each winter been hauled in this way by the farmers of Aroostock county, who esteem it highly as a fertilizer for their crops of potatoes, large quantities of which are grown in that region for the manufacture of starch. It is stated that upwards of a thousand tons have been taken away in this manner in a season.

There are now two mills on the Tobique, one at Three Brooks and the other at Quaker Brook, which are fitted with machinery for grinding the gypsum, but owing in a large measure to the poor facilities for shipment their operations are on a very limited scale. This drawback, the want of means of carriage, will, it is expected, soon be done away with, as a railway is projected, and surveys for it have been made, to run up the valley of the Tobique as far as the gypsum beds. Connecting at the mouth of the river with the New Brunswick railroad system, it will afford an outlet for the plaster as well as for the lumber and other products of the districts.

Limestones.—The only deposits of limestone known in this district, which give promise of burning to form good lime, are of Lower Carboniferous age and occur near the summit of that series on the Tobique. They occur in thick beds at several points along the river above the Wapskehegan; many of these beds are too silicious for calcination, but there are among them some of good quality which would probably yield good lime.

The slates of Silurian age throughout this tract are, over large areas, highly calcareous and are often banded with layers of fine pure limestone; none sufficiently pure for calcination have been noticed.

Building Stones.—Some of the sandstones and grits of the Lower Carboniferous formation on the Tobique seem to be well adapted for building stones. They vary in texture from fine-grained sandstones, approaching freestones, to coarse grits and conglomerates; and in colour, from white, through pink, to purplish-red. Their hardness is equally variable, and as they occur at different points in massive beds, it seems probable that they may furnish good building material.

Roofing Slates.—Mr. Hind mentions the occurrence of excellent roofing slates on the right hand branch of the Tobique River, below the forks of the Serpentine.

Brick-clays.—Clay which seems well adapted for the manufacture of bricks occurs in thick beds at several points along the St. John River. Owing mainly to the limited demand it has not yet been utilized to any extent.

Marl.—Considerable deposits of this material, which is valuable as a fertilizer, were noticed in the bed of a small lake, lying on Lower Carboniferous limestone, a short distance above Burnshaw Brook, on the right bank of the Tobique. Many others of the small lakes throughout the district, notably those lying on the highly calcareous strata of the Silurian, are likely to yield it.

Gold.—The discovery of gold has been from time to time reported from almost every part of this region. Up to the present, however, the only finds which can be regarded as authentic have been made by washing the drift, and these have nowhere been rich enough to indicate that extensive working would give remunerative results. Mr. Hind reports the occurrence of fine gold, in small quantities, in the drift in many places throughout the region—notably "in a valley on the north side of Blue Mountain."*

None of the numerous quartz veins throughout the district have yet been found to be auriferous; the only discoveries of this metal, which are considered to be well authenticated, are those from the drift.

* Preliminary Report on the Geology of New Brunswick, by Henry Youle Hind, M.A., F.G.S., Fredericton, 1865.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON

GEOLOGICAL SURVEYS AND EXPLORATIONS

IN THE COUNTIES OF

GUYSBOROUGH, ANTIGONISH, PICTOU,
COLCHESTER, AND HALIFAX,

NOVA SCOTIA,

FROM 1882 TO 1886.

BY

HUGH FLETCHER, B.A.,
AND
E. R. FARIBAULT, C.E.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1887.

To ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S.
Director of the Geological and Natural History Survey.

SIR,—I have the honor to submit herewith the reports of Mr. E. R. Faribault, C.E., and myself, on work done during the summers of 1882 to 1886, in the counties of Guysborough, Antigonish, Pictou, Colchester and Halifax, Nova Scotia, as described in the summary reports for 1880-81-82, page 21; 1882-83-84, page 14; 1885, pages 22 A and 62 A, and Report of the Department of the Interior, 1886, Part III., pp. 31 and 32.

Mr. Faribault has devoted himself to an investigation of the gold-bearing rocks of the Atlantic coast, and was assisted in the field by Messrs. M. H. McLeod and Archibald Cameron, while I have been aided, both in the field and office work, by Mr. J. A. Robert, B.Ap. Sc. and Mr. John McMillan.

As in previous years, the greater part of our time has been spent on topographical surveys; and a map on a scale of one mile to an inch, has been constructed almost wholly from these surveys, and laid down on a projection prepared by Mr. Scott Barlow, who also reduced from the Admiralty charts the coast line between the Strait of Canso and Pictou Harbour, thus connecting the present map with that of the Pictou coal-field, drawn by him on the same scale for Sir William Logan and published in the Report for 1866-69.

I have again to thank many gentlemen for information, assistance, and hospitality, but more especially the following:—Sheriff Hill, E. G. Millidge, C.E., H. C. Smith and W. B. Robb, of Antigonish; Charles Lundy, Superintendent of the Direct Cable Company, Tor Bay; E. D. Arnaud, of Annapolis; Rev. John Chisholm, P.P. of Heatherton; Rev. Peter Forgeron, P.P. of Harbour Bouché; Archibald McPhee, of Upper South River; Alex. Manson, of North Side Lochaber; Wm. Giroir, of Giroir's, Tracadie; E. J. Cunningham, Postmaster of Guysborough; Jeffrey McColl, M.P.P. and Abram McDonald, of New Glasgow; Capt. Angus McDonald, of Cape George; Dougald Angus McDonald, of Malignant Cove; Joseph McDonald, of McAra's Brook; Henry Dunbar, Evan Ross and Alex. McDonald, of Sunnybrae; Wm. McDonald, of Barney's River Station; David Walker, John Cameron, Wm. Henderson, of Big Island, Merigomish; David Huggan, of Avondale; Jas. R. Mackenzie, of Roy Island; Chas. J. Macdonald, P. O. Inspector; Edwin Gilpin, Inspector of Mines; Dr. Honeyman, Curator of the Provincial Museum, and James H. Austen, of Halifax; Henry S. Poole, Manager of the Acadia Coal Mines, Stellarton; John Rutherford, M. E. of Albion Mines; Ambrose F. Church, of Bedford; T. M. Williams, of Mine Hill, N.J.; F. N. Gisborne, Superintendent of Government Telegraphs, and Collingwood Schreiber, Chief Engineer of Government Railways, of Ottawa.

I have the honor to be, Sir,
Your obedient servant,

OTTAWA, *March 14th*, 1887. HUGH FLETCHER.

REPORT

ON

GEOLOGICAL SURVEYS AND EXPLORATIONS

IN THE COUNTIES OF

GUYSBOROUGH, ANTIGONISH AND PICTOU,

NOVA SCOTIA.

By HUGH FLETCHER, B.A.

INTRODUCTION.

The following report relates to the geology of those portions of the counties of Guysborough, Antigonish and Pictou, which lie north of the gold-bearing series of the Atlantic coast and east of Sutherland's River and of the Pictou coal-field—a region which presents in its geography, geology and scenery, many interesting features. The highest land extends along the Gulf shore from Cape George and Morristown to the East River of Pictou; but few of the summits exceed 1,000 feet in height, and deep, broad valleys are cut by the Salmon, Guysborough, Pomquet, Antigonish, St. Mary's, Barney's, French and Sutherland's Rivers. Area surveyed. General features.

The northern part, including nearly all Antigonish and a large portion of Pictou county, is well settled. Guysborough county is in general much less productive and contains large uninhabited tracts of woodland and barren.

GEOLOGY.

There seems no reason to believe that any one of the formations between the Triassic and the Pre-Cambrian is absent from Nova Scotia. Those found in Cape Breton are also found on the mainland with others of Lower Cambrian age—the gold-bearing series—Silurian, Cambro-Silurian and Permian, most of which are also traceable through Cumberland county* into New Brunswick. No gap in the geological formations from Pre-Cambrian to Permian.

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* Geol. Survey Report for 1885, page 54 E.

Distribution of the Pre-Carboniferous formations.

The large Pre-Carboniferous metamorphic area, eighteen miles wide at the Strait of Canso, narrows near Lochaber, about thirty-five miles to the south-westward* to less than five miles: then widens again to about eighteen miles between the Carboniferous basins of Merigomish and East River of St. Mary's, sending an unbroken spur along the sea shore from McAra's Brook to Livingstone Cove, near Cape George.

Composed largely of Devonian and Cambro-Silurian rocks.

This area, described by Sir J. W. Dawson,† instead of being Silurian as supposed by him, includes, from the Strait of Canso to Lochaber, only the plant-bearing Devonian strata described in previous reports,‡ and to the north and west, chiefly Cambro-Silurian and older formations.

Gesner's map.

On Gesner's geological map of Nova Scotia, published in the Proceedings of the Geological Society of London for 1843, p. 280, the rocks about Chedabucto Bay are called metamorphic and Silurian, but the Carboniferous area of River Inhabitants is colored in the same way, while all Madame Island is referred to the gypsiferous series, the southern metamorphic portion having probably not been examined. Mr. Brown's views on these rocks are given in the Proceedings of the same Society, Vol. iv., p. 424.

Areas of Silurian rocks.

Small areas of Silurian rocks, holding characteristic fossils, are found resting unconformably on the older formations: (1) at Cape George; (2) at Arisaig; (3) at Vamey's Brook; (4) in the valley of Marsby Hope; (5) at Lochaber; (6) in a basin extending southward from Avondale up Barney's River and across French River toward Sutherland's River; (7) in a small basin at Moose River; (8) in irregular, broken outcrops extending from Kerrowgare down the East River of Pictou, where fossils have been collected and described by Sir J. W. Dawson, Dr. Honeyman, and others; (9) in a small area north of Sutherland Lake.

A rich and interesting field of research is presented by the Cambro-Silurian rocks, from which few fossils have yet been collected, more attention having been given to unravelling the structure of this hitherto little known series.

Areas of Carboniferous rocks.

Carboniferous rocks occupy three well marked belts often folded obliquely to the longer axis. These are: (1) The St. George's Bay basin, perhaps containing no beds higher than the Carboniferous limestone, extending from North Canso to Ohio, thence northward to Cape George, but broken at Antigonish Harbour by bosses of older rocks, the largest of which runs from the Sugar-loaf Mountain to Morristown; (2) the Merigomish basin, extending from McAra's Brook westward

* All the courses given in this report are astronomical, the variation being about 24° 15′ west at the Strait of Canso. They are reckoned in degrees from the north, 0°, by east, 90°, south, 180° and west, 270° to 360°.

† Acadian Geology, pp. 558 and 568.

‡ Geol. Survey Report for 1877-78, p. 16 F. and Report for 1879-80, p. 32 F.

to the Pictou coalfield and overlain by the Permian of Big Island; (3) the St. Mary's basin, the fossil plants of which would indicate either a Millstone Grit or Lower Carboniferous age;* but the altered aspect of the rocks would rather refer it to the latter; it extends from the neighborhood of Salmon River Lakes to the head of West River, St. Mary's, and is mentioned by Sir J. W. Dawson in his Supplement to Acadian Geology, page 49, and in Lower Carboniferous Plants, page 10.

The strata may be classified as in the following tabular view:— Classification.

G. 4. Permian,	New Glasgow conglomerate and rocks of Big Island, Merigomish and Pictou Harbour.				
G. Carboniferous,	G. 2. Millstone Grit.				
	G. 1. Carboniferous limestone.				
	G. 1 m. " conglomerate.				
F. Devonian,	Upper red slate and sandstone group.				
	Middle gray slate " "				
	Lower conglomerate " "				
E. Silurian,	E. 6. Lower Helderberg,	Div.	D.	of Dr. Honeyman,	at Arisaig.
	E. 3. Niagara,	"	C.	"	"
	E. 2. Upper Clinton	"	B′.	"	"
	E. 2. Lower Clinton	"	B.	"	"
	E. 1. Medina,	"	A.	"	"
D. Cambro-Silurian,	Upper sandstone and conglomerate of Bear's Brook.				
	Middle shale and sandstone of Baxter's Brook.				
	Lower flinty slate and sandstone of James River & Eigg Mtn.				
A. B. Pre-Cambrian?	Felsites of the shore at Doctor's Brook and Georgeville; syenitic rocks of Ohio; and schists of Sutherland's River and Garden of Eden.				

Volcanic rocks are associated with these groups as high as G. 1 m, while a large proportion of the material of the Cambro-Silurian and Pre-Cambrian is apparently of volcanic origin. Volcanic rocks.

A. B. Pre-Cambrian?

Doubt concerning the position of these rocks.

In this division will be classed provisionally, on the authority of Dr. Honeyman, the felsitic rocks of Georgeville, Doctor's Brook, and Arisaig on the Gulf shore, which are, at least, older than Medina; the syenite, felsite and allied rocks between the head of the West River of Antigonish and Garden River, upon which rest, unconformably, patches of Cambro-Silurian strata; and the gneisses, schists, and syenites at the base of the Cambro-Silurian, west of Garden River, at the head of Sutherland's and Moose Rivers and elsewhere. That part, or all of these rocks may be Cambrian, or even Cambro-Silurian, cannot be gainsaid; but they are the lowest found in the region, resemble no rocks known as Cambrian in other parts of Nova Scotia, are strikingly

* "The faunæ of the seas of the Lower Carboniferous coal formation and Permian periods, both in Europe and America, present so great similarities that they may, in a broad view of the subject, be regarded as identical."—Acadian Geology, p. 283.

like those beneath the Upper Cambrian in Cape Breton, and those called Pre-Cambrian by Dr. Ells, in the Cobequid Mountains.* But it must also be borne in mind that similar gneisses and schists at Canterbury, N.B., have been included by Professor Bailey† in the base of his Cambro-Silurian series; and that large masses of red syenite, cut Cambro-Silurian rocks at James River and other places.

Georgeville Crystalline Rocks.—In the great variety of rocks which occur in the narrow belt along the shore between Livingstone and Malignant Coves, there are probably more than the three Pre-Carboniferous series at present recognized. The two lowest of the latter are cut by syenite and granite, and all are unconformably capped by Carboniferous conglomerate. The extreme care necessary to trace the boundaries of these formations is thus shown; and still further examination will be required to clear up all difficulties. The lowest are regarded by Dr. Honeyman‡ as Laurentian, because of their resemblance to those of George River.

Intrusive rocks

The pink, purplish and greenish flinty felsites and quartz-felsites, veined and spotted with quartz and epidote, at the mouth of Malignant Brook, are probably contemporaneous with, or newer than the Cambro-Silurian conglomerate with which they are associated; whereas the coarse crystalline diorites and syenites on the rough shore to the eastward are older, but break through the slates, banded felsites and crystalline limestones. The latter are not extensively developed, so that little can be said of them. The felsites, like those of Arisaig, hold epidote and quartz in blotches and veins; they are generally greenish-gray or gray with pink blotches; have chlorite and calcspar in the joints, which are so numerous that the rock breaks into small pieces under a blow of the hammer; and are not unlike the obscurely granular felsite of Capelin Cove.

Malignant Brook.

The limestone is gray, bluish-gray, whitish and greenish, of varying purity, with indistinct bedding, serpentinous, and showing Eozoon-like wrinkles, compact to broady crystalline, holding small ferruginous patches, in one place forming a cliff twenty feet high, and apparently of great thickness. A quartz vein, eight feet thick, separates a mass of diorite from the limestone on the eastern side.

Crystalline limestone of Georgeville.

Quartz vein.

Immediately east of the road from Malignant Cove to Greendale, a small brook presents exposures of dark-bluish gray and greenish rocks, obscurely crystalline, finely banded, resembling mica-schists, but containing also patches of fine hornblendic rock, into which they appear

Greendale.

* Geol. Survey Report for 1885, p. 54 E.
† Geol. Survey Report for 1882-83-84, p. 13 G.
‡ Journal Geol. Soc. 1870; Trans. N.S. Inst. Vol. II., p. 196, Vol. III., p. 35, Vol. IV., pp. 58 and 454.

to pass, and which resemble concretionary masses. Above these are steel-gray and dark, flinty, quartzo-micaceous, banded strata, cut along the bedding by a dyke of fine crystalline diorite, three feet wide.

On the road near Greendale are outcrops of dark greenish dioritic flinty slates or schists, with scales of specular iron ore, large blotches of milky quartz, fine golden mica and minute fibres of black hornblende, either cut by, or passing into coarse syenite for a few feet, and interstratified with chloritic and epidotic, very massive schists, strikingly resembling the rocks described by Dr. Selwyn at Yarmouth,* which are probably also Pre-Cambrian. In a brook, near the sea shore, are greenish, epidotic, imperfect schists or slates, and massive syenite and diorite, which at the shore contain quartz-veins eighteen inches thick, and are not unlike greatly altered Cambro-Silurian slate and flinty, compact sandstone, mixed with igneous deposits. The soft, serpentinous, calcareous, whitish rocks of the shore north-east of the mouth of this brook, are peculiar. Near the brook a rock, probably volcanic, becomes more trap-like to the eastward and pinches out the last of the limestone, which is here a bluish-gray banded variety. Succeeding it are rocks like those of Capelin Cove, mentioned above. The boundaries of the schistose and coarse dioritic rocks are shown as nearly as possible on the map.

Iron ore.

Resemblance to the rocks at Yarmouth.

Quartz veins.

On the shore road, about one mile west of Georgeville chapel, is an outcrop of crystalline limestone, the only one seen inland.

Crystalline limestone.

Felsitic Rocks of Doctor's Brook and Arisaig.—Of these, as of the foregoing, it should be remarked that although they closely resemble the Louisburg and Coxheath Pre-Cambrian, they may be of any age older than Medina, and have been regarded both as metamorphosed sedimentary, and as volcanic rocks. Full details regarding them have been given by Dr. Honeyman and Sir J. W. Dawson.† They strike in a narrow broken belt along the shore between Arisaig pier and McNeil's Brook, and are cut by amygdaloid of Lower Carboniferous age. On the rocky point of Arisaig pier and on a neighboring knoll they consist of red and yellowish, flinty, compact quartz-felsite and quartzite, but further east pass into fine grained syenite. The interstratified band of dysyntribite, which is traceable for about a mile, is a soft rock, of green, whitish yellow and other colors, about fifty feet thick, apparently underlying the rocks of the pier, and associated with red or brown, shaly, fragmental Louisburg shales, of considerable variety of color, containing spheroidal concretions, two feet and less in diameter, composed also of fragmental rock.

Of doubtful age and volcanic origin.

Arisaig pier.

Dysyntribite.

*Geol. Survey Report for 1870-71, page 271.

† Trans. N. S. Inst. Nat. Sc., Vol. III., p. 233; Vol. IV., pp. 53, 60 and 457; Vol. V., p. 271; Acadian Geology, p. 567, and Supplement, p. 90; Journal Geol. Soc., Vol. VI., p. 347, and Vol. XX., pp. 339 and 341.

Frenchman's Barn.

Brown and pink quartz-felsite form the high cliff called Frenchman's Barn, to the eastward of which is an indian-red and yellowish-green shaly variety, made up of grains about as large as peas, every grain having a radiating globular structure. After an interval of about half a mile, occupied by Silurian fossiliferous strata, the shore east of Beech Hill Cove again affords good exposures of greenish, yellowish, and reddish quartz-veined, flinty, compact or obscurely granular and fragmentary felsite and quartz-felsite, with obscure, bent and irregular planes of bedding or jointing, associated with dark amygdaloids, apparently striking with the felsites and containing shaly layers and bands of rocks like those of Louisburg and Cape Rhumore.* These occupy the coast to Doctor's Brook, to the eastward of which are blackish, greenish and brownish shaly amygdaloids, reddish and purplish flinty felsite and similar rocks.

Beech Hill Cove.

Doctor's Brook.

In Doctor's Brook, below the bridge on the shore road, the "picturesque exposures of singularly mixed and indescribable rocks" of this famous trout-brook belong to this series near its contact with Medina fossiliferous strata. Not the slightest alteration is apparent in these latter, which are full of their characteristic fossils one foot from the contact. On the left bank, above the mill-dam, the felsites might at first sight be mistaken for reddish altered Cambro-Silurian grit; but seem in every case on closer examination to be finely fragmental Coxheath felsites, a conclusion supported also by a microscopic section made by Mr. T. C. Weston.

Microscopic section of volcanic rock.

Rory McDonald's Brook.

At the mouth of Rory McDonald's Brook, reddish-gray flinty felsites are again in contact with evenly-bedded Medina shales; while on the reefs are the reddish and greenish, shaly and thick-bedded, soft, trap-like rocks of Cape Rhumore, which so often resemble sandstone and conglomerate, but are evidently of volcanic origin.

Two varieties.

Crystalline Rocks of the Keppoch, East River of St. Mary's and Upper Barney's River.—The crystalline rocks of the hill country east of Garden River consist chiefly of syenitic, dioritic and felsitic strata, rightly placed below the fossiliferous Medina by Dr. Honeyman, who considers them also Archæan;† while those west of that river are for the most part laminated or schistose. It is doubtful whether these rocks are not in great part newer, as their contact with Cambro-Silurian strata would sometimes seem to prove; but the quantity of volcanic material in the latter is so great that these may be only the contact of dykes, whereas isolated patches of comparatively unaltered sedimentary rocks belonging to a later period are found within the felsitic

* Geol. Survey Report for 1875-76, p. 379; for 1876-77, pp. 419 and 425; and for 1877-78, p. 8 F.
† Trans. N. S. Inst. Nat. Sc., Vol. V., p. 206.

areas. On the hill west of Lochaber, fossiliferous Silurian rocks are underlain by a ridge of trappean, fragmental and porphyritic felsites, like those of East Bay and Louisburg, showing lines of obscure bedding, frequently dioritic or passing into red syenite, and associated with greenish or gray, fine-grained or compact, splintery, pyritous, micaceous diorite, hardly distinguishable from fine sandstone, with threads and druses of quartz. These rocks are seen both on the streams flowing into Lochaber and into MacGillivray's mill-brook, in which latter they comprise greenish and purplish, compact, fine-grained and fragmental, Coxheath felsite, with traces of calcspar, hæmatite, epidote and serpentine. North of McNab Brook, compact gray or greenish-gray porphyritic felsite or diorite, blotched with quartz, is mixed with flesh-red compact quartz-felsite, greenish-gray granular felsite, whitish-purple porphyry, with the oblique slaty cleavage of the Coxheath aluminous shales, and the prevailing red syenite of Upper Ohio. The contact of the Silurian rocks is here so abrupt, that without a fault, the felsites could not be regarded as intrusive among, or newer than the former, only three feet being concealed between the felsites and a series of little altered greenish and gray fossiliferous argillites or dark slate and flaggy fine sandstone, veined and blotched with quartz. A ridge of high land indicates the extension of the felsites northward to a point behind John McNaughton's, where traces of copper pyrites are found in connection with blotches of quartz.

Lochaber.

McGillivray and McNab Brooks.

Contact with Silurian rocks.

Copper ore.

Similar rocks are cut through by the brooklets which enter the West River of Antigonish, on the west side, above Beaver Meadows. On the first of these brooks, opposite St. Joseph's chapel, they underlie a gray, coherent, Carboniferous limestone, which has been quarried; they consist of very light-colored and greenish-gray, splintery, compact, obscurely porphyritic and granular felsite and quartz-felsite, containing spots of hornblende, chlorite, epidote, hæmatite and other minerals; and of beautifully mottled felsite, much of which is granular. On an adjoining brook, are gray, compact, flinty felsite and quartz-felsite, sometimes light in color, resembling the variety at Coxheath fit for fire-clay, but containing specks of pyrites. Along the hill, near the Ohio cross roads, felsites underlie carboniferous limestone, the boundary of which has been closely traced. They are of the usual colors, hold veins of white quartz, loose blocks of which one foot in diameter lie around, and they pass into syenite or into beautifully mottled, fragmental, coarse felsite-breccia and epidotic porphyry, containing traces of copper.

West River of Antigonish.

Contact with Carboniferous.

Quartz veins.

Copper ore.

The dark greenish-black color of the rocks in the large brook south of the cross roads, indicates their hornblendic character. They are succeeded upstream by a lighter greenish granular mixture of felspar and hornblende, which extends to the Keppoch road.

Keppoch.

Hæmatite. The adjoining brook displays dark greenish, obscurely granular diorite and red and green syenite, containing minute veins and crystals of quartz, with specks and films of hæmatite. The syenite sometimes contains mica, but in the next brook to southward, passes into red, nearly compact quartz-felsite, shown in fine cliffs.

Upper Ohio. Near the head of the Ohio settlement, the prevailing Pre-Carboniferous rock is red syenite.

On Callahan Brook, Carboniferous limestone immediately overlies gray, purple and reddish syenite and felsite, traps, tuffs and amygdaloids, the relation of which to the succeeding bluish and greenish flinty slates is obscure. These slates are apparently Devonian, but possibly Cambro-Silurian, probably altered by the traps, which, however, are not clearly of the same age as the syenite and felsite. These traps, however, may be of the same age as the syenite that cuts the Cambro-Silurian strata of James River. The next brook exposes only reddish-gray, coarse and compact syenite like that of Stewart's and of the upper dam on the West River, containing a minute quantity of hæmatite; while in the river, immediately above the foot bridge, are gray felsite and purple trap. Below the bridge at Stewart's, the unconformity of the syenite and of the Carboniferous strata is well shown, the former here containing minute scattered traces of specular iron, explored in several pits.

Volcanic rocks of Callahan Brook.

Iron ore.

Garvie Lake. On the track between John Carroll's and Garvie Lake, light-gray, compact, flinty quartz-felsite, with glittering grains of vitreous, colorless quartz, passes into flinty porphyry and red syenite.

Dioritic rocks are also found in great abundance in this neighborhood, with blocks of purplish trap; and above the settlement on the West River, bluish-gray, compact felsite accompanies the red and gray syenite of the road from Ohio to the Black Brook of St. Mary's, but is interrupted by outcrops of green slate. At the head of Big Meadows Brook, porphyritic felsite of reddish-gray and other colors, showing its fragmental structure on weathered surfaces, is in place, near reddish-gray, not greatly altered sandstone, probably upper Devonian.

St. Mary's.

Beaver River. In the branch of Beaver River, below McIsaac's, at the county line, are exposures of reddish and of gray, compact, flinty felsite and quartz-felsite.

Below the fork of the branch from the little lake to the eastward, gray, greenish and red flinty felsite and greenish porphyritic diorite appear as far as the crossing of the road to McLean's. The relation of these rocks to the Cambro-Silurian siliceous slates of the vicinity is obscure. Near the fork of the brook flowing from McEachern's Lake, are outcrops of bright red syenite and gray fragmentary Louisburg felsite. That one of the outcrops of felsite is newer than the

slates, seems to be certain, but that the red syenite is also newer, requires further proof. Gray and blackish, fragmental, Louisburg breccia and bright-red, compact, flinty felsite, passing into syenite, are also seen at the cascades, with fine, pyritous diorite. On the hauling-road from this branch to Angus McDonald's, greenish Cambro-Silurian slate is found near the clearings; while felsite and diorite occur for three-quarters of a mile from the river. In the upper part of the river, no rocks are met with, and the felsites, diorites and quartz-felsites, which form the southern boundary of the green slates in Coillteach Brook, more closely resemble newer intrusive rocks than Pre-Cambrian, and those at the mine in the branch from McEachern's Lake, appear also to be mixed intrusive and sedimentary. At the shaft, greenish-gray and whitish, very flinty, porcellanous rock, full of cubes of pyrites and threads of quartz, has been mined; but the veinstone shows only chlorite. The syenite in the immediate vicinity would appear to alter the slates: it extends up to the lake, and is exposed in rocky gorges, and at cascades, then passes into quartz-felsite. Between the lake and the Black Brook road, are blocks of hornblendic slate. From the lake westward to Andrew McKay's, the soil is bad, and is strewn with blocks of coarse, white or flesh-colored granite, composed of transparent milky or colorless quartz, pinkish felspar and light or silver-gray mica, the mica being in small proportion or altogether absent.

Sedimentary rocks of the "mine" in Beaver River.

On the middle branch of Barney's River are felsites, diorites and similar rocks, not belonging to this division, but cutting Cambro-Silurian slates.

Barney's River volcanic rocks.

Above the road to Forbes Lake, crystalline rocks are very abundant, consisting of granular diorite and gray or reddish syenite. At the outlet of the other smaller lake is a ledge of greenish fine diorite, compact felsite and reddish syenite containing little hornblende. In the little brook east of John J. Robinson's, greenish felsite and diorite are succeeded downstream by Cambro-Silurian quartzites. In the neighborhood of the Rossville school-house, dioritic rocks are in place, and diorite, syenite and felsite in the brooks between this settlement and the west branch. Where they come in contact with Cambro-Silurian slates, the latter do not seem to be more porcellanous than usual. In the west branch of Barney's River, apparently mixed with the Cambro-Silurian conglomerate, described elsewhere, are outcrops of reddish and greenish, compact, porphyritic felsite, quartz-felsite, fine diorite, red syenite and allied rocks, perhaps intrusive, perhaps belonging to this division. Higher up, in cliffs and at cascades, are seen red syenite, or a gray coarse mixture of felspar and hornblende with very little quartz; and still higher, the prevailing rock is syenite, with, occasionally, felsites. The rocks are well exposed in the roads, fields and brooks, while on the

Forbes Lake.

main river, above Robert McKay's, outcrops first of red syenite, then of dark gray, pyritous, porphyritic fine felsite and diorite, with bright-red syenite, extend to the Marsh settlement and thence past Brora Lake.

That some of the porphyritic rocks of this river are older than the Cambro-Silurian conglomerate seen lower down, is almost certain; for the well-rounded pebbles of the conglomerate often consist of fragments of felsites.

Brora Lake. On the shores of Brora Lake, gray and reddish syenite, and bluish, massive felsite and felsitic slate, are associated with red slates, perhaps Cambro-Silurian. On the road from the Garden of Eden to Barney's River, felsites are seen in many places, succeeded by the schists of the next division, and syenite and felsite occur also between the Garden of Eden and Beaver Lake. Campbell Brook. In Campbell Brook, quartzites and conglomerates, perhaps Cambro-Silurian, seem to be in patches among compact and granular, massive felsites, with blotches of milky quartz, associated with felsitic slates of various colors, succeeded upstream by brownish conglomerate, composed of the foregoing rocks, and succeeded again by gray, flinty, massive and laminated felsite.

In both branches of the brook, many varieties of fragmental Coxheath felsite, aluminous slate, red porphyry, syenite and hornblende rock, are found, as well as in the Garden River, but here again they are St. Mary's roads. perhaps, in part at least, intrusive. All the rocks on the road between the Garden of Eden and Rocky Mountain, consist of syenite and felsite of varieties similar to those which are also found on the road to Green Settlement, and on that toward William Brady's. On the road past Thomas McBean's, back to the post road, the felsites are succeeded by bluish-gray slates and other rocks, perhaps Cambro-Silurian.

Reddish syenite, often coarse, occupies most of the road between the Black Brook of East River, St. Mary's. Keppoch and Black Brook, and thence to the main road at East River.

Above the settlement, Black Brook exposes bluish-gray, massive felsite and quartz-felsite, succeeded in the west branch by red and gray flinty slates, probably Cambro-Silurian, but giving place higher up to felsite, syenite and diorite of different colors.

Black Brook lakes. On the upper lake in the settlement are outcrops of red, nearly compact syenite, without much hornblende, of felsite and of dark-gray, coarse diorite, veined with epidote. Above the second lake, syenite forms the walls of a rocky gorge with a fine pool, while below the lake is a celebrated dome-shaped fall, thirty-five or forty feet high. Immediately above the road, at this lower lake, are large outcrops of coarse, reddish and pink quartz-felsite, passing into syenite and mixed with diorite; and similar rocks extend to McKay Brook, where they are overlain by dark slates and quartzites of doubtful age.

Jordan Brook. In Jordan Brook, below Cameron's marsh, mottled red, gray and

green, obscurely granular and compact felsite, passing into red syenite, is associated with gray, softer felsite, and a band of breccia, like that carrying the copper at Coxheath.* In the other branch is a bright-red and mottled felsite.

Crystalline and Schistose Rocks of Moose River, Blue Mountain and Sutherland's River.—These rocks, supposed by Dr. Honeyman† and Dr. Ells to be Pre-Cambrian,‡ and now admitted by Sir J. W. Dawson § to be as low as the base of the Cambro-Silurian, extend in a belt, several miles in width, from the Garden of Eden up Moose River to Blue Mountain and McLellan's Mountain, where they are overlain by Cambro-Silurian and Silurian strata. Their most easterly outcrop seems to be in Campbell Brook, in connection with coarse conglomerate, flinty grit and quartzite, probably upper Cambro-Silurian, and reddish-green syenite or felsite; red, white-spotted, fragmentary felsite; variegated red, whitish and purple felsite, like that of the Green Settlement school house; fragmental, soapy and soft aluminous slates, weathering to look like grit, of great variety of color, and containing specular iron. Extent.

Felsites and fragmental slates are also found on the west side of Eden Lake, and in Moose River above the lake. How they are related to the Cambro-Silurian rocks at the copper mine is uncertain; but fragmental slates are here also present. Eden Lake, Moose River.

Pearly talc and mica-schists, containing spots of quartz, occur in Moose River below Barney's River road, with greenish, porphyritic, fine diorite; they are sometimes chloritic and closely associated with light-gray, flinty, siliceous, Cambro-Silurian slates, like those of Eigg Mountain. Lower down are pearly, scaly slates, containing serpentinous matter, and giving a beautiful play of colors. These consist, essentially, of quartz and felspar, and are interstratified apparently with fragmental rocks, perhaps fit for fire-clay.

In the large mill-brook from the north, are dark-greenish or gray pyritous, fine diorite or felsite; porphyritic and fragmental, epidotic, quartz-felsite, with films of hæmatite in the joints; soft Coxheath slate, often fragmental and full of scales of specular iron; below these are compact and granular felsite, and higher up the stream, schists, granular slates and crypto-crystalline, fragmental felsites. In the east branch of French River, for some distance above Manning Mountain road, are good outcrops of compact and granular, flinty felsite and quartz-felsite, passing into reddish and gray syenite. Higher up, the river runs in Traces of iron ore. East branch of French River.

* Geol. Survey Report for 1879-80, p. 128 F.
† Trans. N. S. Inst. Nat. Sc., Vol. V., p. 206.
‡ Geol. Survey Report for 1885, p. 54 E.
§ Supplement to Acadian Geology, p. 80, and Can. Naturalist, Vol. IX., No. 6.

cascades over greenish, and dark, fine diorite and light-gray, flinty crystalline, porphyritic quartz-felsite, the latter, still further up stream, becoming obscurely gneissic and mixed with dioritic, talcose, syenitic and chloritic rocks. Then come very slaty, coarse-grained, talcose granite or gneiss; gray, fine, silvery, pearly talc-schists; flinty felsitic and quartzo-felsitic slates, full of quartz veins, often pyritous. Similar schists occupy all the country hereabout, extending eastward to the head of Garden River.

Foot road.

On the Foot road, south of the fine outcrops of Cambro-Silurian grit and slate near Glenshee, occurs a band of greenish, nearly compact felsite; pearly, soapy slates or schists, like those of Sutherland's River; micaceous hornblende-schists; silvery and pearly, talcose, chloritic and mica-schists, resembling a fragmental rock and with hard spots of quartz in imperfect crystals and grains. The schists are in many places veined with quartz, and extend to the road at Moose River post-office; in the valley of the river there is, however, a belt of Silurian. On the road from Moose River to Blue Mountain, schists and fragmental felsites extend for some distance, but require further examination.* On the track between Robert Chisholm's and Smith's Lake, are schistose felsites, syenite and Silurian strata.

Silurian outlier

Head of the East River of Pictou.

Sutherland's River.

Below the Blanchard road, also on Sutherland's River, are aluminous slates, resembling those of Coxheath; among them an impure variety of the fire-clay, fit for pottery,† with its characteristic interlocking plates. A red, compact porphyritic felsite, and a pearly, fine, soft, soapy, mottled, scaly shale, passing into a granular rock resembling a grit, are also present. Greenish, soft, fragmentary Louisburg shales: red, flinty, quartz-veined felsite; light-greenish, shaly, flinty felsite and similar rocks are, above the bridge, cut by dykes of dark-green diorite; they extend to the McInnes Settlement and beyond, toward the East River of Pictou.

In the neighborhood of Sutherland's Lake, are reddish-gray, compact and granular felsite and quartz-felsite. In the marshes near the small lake to the southward, these rocks are in contact with Medina fossiliferous strata, and extend thence to Smith's Lake.

Silurian rocks.

Silurian rocks occupy the road down the west side of Sutherland's River, from the Blanchard Road school-house to the bridge at Archibald Fraser's, where large blocks of fossiliferous sandstone are found. On crossing to the east side of the river, however, blocks of felsitic, hornblendic and other schists occur, mixed lower down with others of Silurian rock.

On a by-road to the right, up a brook, Silurian sandstone is in place

* Trans. N. S. Inst. Nat. Sc., Vol. V., p. 206.

† Geol. Survey Report for 1875-76, page 428.

for some distance; but beyond it on the main road are schists, some of which greatly resemble the Eigg Mountain Cambro-Silurian slates, to which series they may possibly belong, as well as the rocks at the falls of the river lower down. This point requires further study. The rocks at the watering-trough are, without doubt, Cambro-Silurian. **Cambro-Silurian.**

On the road across Sutherland's Mountain, past Sutherland's Lake to Blue Mountain, reddish, flinty, compact and granular, porphyritic felsite; greenish, soft, fragmental rock; quartz-felsite, with distinct grains of quartz; red syenite and allied rocks, are overlain by Silurian strata. **Sutherland's Lake and Blue Mountain.**

Syenite, diorite, felsite and quartz-felsite apparently cut the schists of Morrison and McGrath Mountains, the schists being of the usual variety and overlain by Cambro-Silurian grits. At the head of the East River of Pictou, between Smith's Lake and the Garden of Eden, the gray diorite, syenite, felsite and fragmental rocks are similar to those between Eden Lake and Black Brook, while everywhere in the neighborhood are patches of soft slate and sandstone belonging to the Cambro-Silurian, Silurian and Devonian systems. Whether the blending of these sedimentary rocks with volcanic matter, often seen along the contact, indicates a subsequent or a contemporaneous origin of the latter, or whether later intrusions have taken place along the line of contact, is yet obscure.

The syenite of Williams Point, Antigonish, and of the eastern side of the harbour* may be Pre-Cambrian, but is perhaps more likely of the same age as that which cuts the lower Cambro-Silurian rocks of James River. It is gray or reddish, coarse or fine, in places almost pure felsite, and sometimes holding black mica. It forms high precipitous knolls of irregular size and shape, rising three hundred feet above the sea, from which fine views of the surrounding country may be obtained; and it is unconformably capped by gray Carboniferous limestone, largely quarried, full of fossils—*Leperditia Okeni*, *Cyrtoceras*, *Conularia* and *Dentalium*—and containing galena. **Antigonish.**

The structure of Cape Porcupine, on the Strait of Canso, has been fully given in the Geol. Survey Report for 1879–80, page 9 F. The slates are more crystalline than those of the Cambro-Silurian, presumably older, and not appreciably altered near the contact of the syenite. **Cape Porcupine**

D. Cambro-Silurian.

The general distribution of the rocks of this system has been already sketched. They are placed beneath the Medina by Dr. Honeyman,†

* Transactions N. S. Inst. Nat. Sc., Vol. III., pp. 33, 37 and 199; Vol. IV., page 72, and Vol. VI., p. 312.

† Trans. N. S. Inst. Nat. Sc., Vol. V., p. 199.

include Sir. J. W. Dawson's Upper Cobequid series,* the grayish conglomerates of Wentworth, and the iron ore series of Londonderry mines.† But both Dr. Honeyman and Sir J. W. Dawson have included as Carboniferous large areas among the mountains, at Malignant Cove ‡ and at Arisaig, in which the strata are of this age.§ Three distinct groups may be recognized, exclusive of the schists and felsites provisionally called Pre-Cambrian :—

Classification.

1. The lower flinty slates, quartzites and "whin"-like rocks of James River and Eigg Mountain ;
2. The soft reddish and olivaceous slates of Baxter's Brook and Brian Daly's Brook ;
3. The reddish and gray sandstone, grit and conglomerate of Bear's Brook.

The junction of the Silurian and Cambro-Silurian rocks is closely and accurately defined on the map ; the boundaries between the subdivisions of the latter require further study and, as they depend chiefly on the accurate determination of three somewhat similar sets of rocks in a region where continuous sections are not often attainable, and where fossils are scarce, some allowance must be made for their indefiniteness. The fossils found belong apparently to the middle group ; they consist only of obscure annelid markings, of a fragment of a cystidean stem and of certain obscure brachiopods. Perhaps, however, a more thorough search will show that they are abundant.

Fossils.

1. *Lower Flinty Slates and Quartzites of James River.*—These rocks, where largely developed, being cut by intrusive masses, chiefly of syenite, it might be supposed that the greater degree of alteration was due to the latter, and that they were only altered strata of the second and third groups. This, however, does not seem to be the case ; on the contrary, they probably underlie the soft shales unconformably.

Antigonish Hills.

An isolated hill-range of sedimentary and volcanic rocks lies west of the shore road from Antigonish to Morristown, including the Antigonish Sugar-loaf and the hills behind Ogden Pond.|| They consist chiefly of greenish-gray flinty, rubbly slates and quartzites, cut by numerous quartz veins and by dykes of syenite, mixed with reddish and greenish, ferruginous, chloritic trap and diorite. In the brook along the old Gulf road, red and green, splintery, pyritous slates are mixed with fragmental felsite. Where they come on the shore at McIsaac Point,

Old Gulf road.

McIsaac Point.

* Acadian Geology, Supplement, p. 79.
† Geol. Survey Report for 1885, pp. 52 and 53 E.
‡ Trans. N. S. Inst. Nat. Sc., Vol. VI., p. 315.
§ The Cambro-Silurian rocks of New Brunswick are described in the Geol. Survey Reports for 1879-80, p. 22 D ; for 1880-81-82, p. 15 D ; for 1882-83-84, p. 13 G, and 1885, p. 23 G.
|| Trans. N. S. Inst Nat. Sc., Vol. IV., p. 70.

Morristown,* they comprise grayish, greenish and reddish, jointed, coherent flaggy quartzite, sandstone or grit, drused with hæmatite; crossed in all directions by quartz-veins, cut by dykes every few yards, and resembling the upper group at Barney's River, but associated with greenish flinty slates like those of James River falls.

Sometimes the grits are so much altered and mixed with traps that at first sight they might be mistaken for felsite-breccias, especially where the dykes run in the bedding. These dykes contain films of hæmatite, calcspar, pyrites and a serpentinous mineral like that of Arisaig. In the lower part of Ogden Brook, Carboniferous conglomerate is underlain by greenish altered pea- and nut-conglomerate or breccia, like that of Beaver River, which appears again at the head of the brook. Rough cliffs of similar rocks are found in different parts of this mountain. On the brooks and roads south of Hallowell Grant post-office, they are more flaggy than usual, perhaps represent the Baxter's Brook group and are covered, near the school-house, by Carboniferous conglomerate.

Dysyntribite (?)

Ogden Brook.

Hallowell Grant.

In the much larger metamorphic area, which, beginning near Cape George, extends along the gulf shore to McAra's Brook, these rocks are again found. On the shore at Georgeville, below Hugh McPherson's house, the dark slates with lighter gray bands resemble the strata of Rogers Brook, Hallowell Grant, all being so jointed that they break into pieces seldom larger than a pigeon's egg. On approaching the coarse diorite which abuts against them on the west, they become more pyritous and porcellanous, and their resemblance to the "whin" of the gold-fields is remarkable. They are cut by dykes of diorite and by a white granular quartzite, containing usually a little hornblende and felspar. To the north-eastward, past two little brooks emptying into a fishing-cove, is another brook, beyond which a dirty-green, flinty, nearly compact conglomerate overlies the slates from which it is largely derived, pebbles of both dark and light-gray slate being numerous, with others of coarse crystalline syenite and diorite. But more abundant than these are pebbles of the quartzite just mentioned. This conglomerate is the same as that of Malignant Cove and probably not higher in the series than the Baxter's Brook group. Black slates and flinty sandstones, belonging also to one of these groups, have numerous small quartz-veins, which in the brook east of Georgeville and near the post-office at Greendale have been mined for silver. At the former place, talc and serpentine occur in some quantity in the vein which is thirteen inches thick, while the planes of the slates contain much graphite and pyrites Similar rocks underlie the conglomerate at the mouth of this brook,

Georgeville.

Conglomerate.

Silver (?) mines

* Acadian Geology, p. 347.

and on the shore road both east and west of it, being well exposed in the little brooks. The various lines of contact of the Carboniferous conglomerate, Cambro-Silurian conglomerate, syenite and slates above described will be seen on the map. Between Livingstone Cove and Ballantine Cove, Carboniferous conglomerate is perhaps everywhere present on the road, but to the south of it, greenish-gray, quartz-veined, James River slates are found in the brooks, and in the branch of Ballantine Brook near McNeil's, contain films of pyrites in the bedding. The light and dark-gray flinty slates and lenticular beds of bluish-gray compact limestone on the shore near Livingstone Cove probably underlie the conglomerate mentioned above, the latter being in turn overlain, not far west of the cove, by Carboniferous conglomerate, containing pebbles of both these groups.

Contact of Carboniferous and older rocks.

Livingstone Cove.

Up the brook about 600 yards southwest of Livingstone Brook, Carboniferous conglomerate is in place for some distance from the shore, but is succeeded below the road by fine outcrops of Cambro-Silurian conglomerate, greenish, fine, rubbly grit and soft quartz-veined slates, like those of Baxter's Brook. The black massive slate near the road might yield fossils, but the exposures are not good. Higher up are cliffs of greenish, quartz-veined, flinty rocks, with soft, very calcareous, dark hæmatitic, chloritic and epidotic trap and diorite.

Volcanic rocks.

The conglomerate and associated Pre-Carboniferous rocks of Malignant Cove apparently represent the higher of the two groups at Georgeville, while underlying them, on the tributaries of Malignant Brook from the westward, are James River sandstone, grit and slate. Not far above the mill at the shore road, search was made for silver in greenish and dark bluish-gray pyritous flinty rock, in thick and flaggy beds, cut by porphyritic felsite and diorite. Near the head of Arisaig Brook, the precipitous walls south of the Hollow are of felsite and diorite, which cut flinty slate and quartzite shown, but without definite dip, at the cascades of the little brooks.

Malignant Cove

Silver (?) mine.

The Hollow.

Above the Trunk road, at the falls and cascades of the steep and bouldery west branch of Doctor's Brook, similar strata are still more largely displayed, comprising greenish-gray compact sandstone or siliceous argillite, crystalline, greenish, pyritous, fine-grained and porcellanous argillite, with a somewhat obscure dip, greatly jointed and cut by dykes of greenish crystalline diorite.

Doctor's Brook.

The volcanic and sedimentary rocks on the east branch of Doctor's Brook, above an outlier of Carboniferous limestone, include patches of bottle-green, flinty conglomerate like that of the Georgeville shore. Farther south on the Pleasant Valley road, are outcrops of greenish fine crystalline rocks; these are also found in the back settlement of Arisaig, the precipitous descent to the Little Hollow probably separat-

Back settlement of Arisaig

ing them from the overlying group. At the head of the various tributaries of the east branch are cascades down cliffs of massive Cambro-Silurian sandstone and slate, sometimes ribanded, and like the former cut by dykes.

Knoydart Brook.

The rocks first seen among the diorites of the head of Knoydart Brook, west of the little lake, belong doubtfully to the Baxter's Brook group; lower down, others of the flintiest description show the bedding by bands of different colors, as they do also at the watering trough near Dunmaglass.

Bailey's Brook.

At the west end of the Hollow, near Bailey's Brook, a knob of flinty sandstone and porcellanous argillite, with indefinite dip, is isolated from the main mass of these rocks in Brown's Mountain by Silurian and Carboniferous strata, or by reddish, sandy grits of the Bear's Brook group. In the mountain east of John McLean's, James River rocks are cut by dykes of porphyritic felsite and diorite.

Vamey's Brook

On Vamey's Brook, greenish-gray, flinty slates and sandstones, intersected by a network of minute quartz-veins, come from beneath the fossiliferous Silurian shales of the lowland and rise into a hill. On the main branch, below the mountain road, fragmental felsite and diorite are associated with slates which, at the road, are somewhat pearly, soft, greenish and finely laminated. The rocks of the west branch of Bailey's Brook and the head of Bruce and Bear's Brooks, are perhaps also of this age. The flinty slates and dykes of Right's River require no special mention. Above Clydesdale, massive, twisted, jointed, ribanded, white-weathering quartzite and slate are cut by dykes of dark crystalline diorite, and hold blotches of quartz and calcspar near the contact; they prevail also in the mountain west of the Pleasant Valley, and on the Brown's and Eigg Mountain roads.

Right's River

James River.

The typical rocks of this group found on James River succeeding red intrusive syenite consist of beds like the foregoing—light-gray and greenish gray, flinty, splintery, compact sandstone or siliceous slate, so coherent that the bedding, always obscure, is here distinguishable only by bands of color. Further up, the beds become more distinct, but are intersected by dark-green fine diorite, blotched with epidote and calcspar. Above the syenite on the first branch from the west, these rocks are full of quartz-veins, some of which are pink, and probably, from the syenite which again succeeds higher up and with alternations of argillite occupies all the district hereabout, and passes sometimes into massive granular felsite or diorite of greenish and gray colors. Near the Brown's Mountain road, and above the falls, are outcrops of whitish, fine, flinty sandstone or quartzite. Below the confluence of two large branches and just above the falls, greenish-gray flinty slates and sandstones are cut by dykes of fine pyritous diorite.

Intrusive rocks.

On other brooks to the westward of James River, syenite and gray diorite cut quartzite and siliceous slate. On one of these brooks, at a fall, is a vein or dyke, two inches thick and downward, of flesh-red, compact, and finely crystalline quartz-felsite, with a few grains of mica and hornblende. The mixture is homogeneous, and the grains not so large in the granular portion as in the syenite, yet the vein probably represents the syenite and is intrusive or newer than the slates. On another brook, associated with the siliceous rocks, is a dark, indian-red and green, coarse, granular diorite; in another, a compact, flesh-red quartz-felsite, holding porphyritic crystals of felspar, probably part of the red syenite mass in contact with the slates along a very irregular boundary and throwing veins a short distance into the latter.

Brierly Brook. On Brierly Brook and other brooks of the neighborhood above the railway are other dykes of reddish syenite in flaggy sandstone and slate. **Iron ore.** West of the main branch are small traces of specular iron. Some of the Cambro-Silurian strata of Kerrowgare and Blue Mountain belong perhaps to this group, but the boundaries have not yet been defined.

2. *Soft Slates of Baxter's and Brian Daly's Brooks.*—The typical rocks of this Middle Cambro-Silurian group underlie the reddish-gray grits of Marshy Hope, apparently unconformably, although the relations of the two groups are often obscure and the boundaries doubtful. **Composition.** They consist largely of contemporaneous volcanic materials, and even the sedimentary beds appear to be, in part, of similar origin. **Baxter's Brook.** On the top of the hill, at the head of Baxter's Brook, outcrops of quartz-veined, flinty, reddish-gray grit, are in place on the winter road from Alexander McDonald's (Weaver) to the head of Beaver River. Eastward from these outcrops the detritus is greenish, smooth, somewhat pearly argillite, which is in place with fine, gray micaceous sandstone in the brook. Upstream, on the main branch above the fork, similar rocks are cut by dark-greenish, nearly compact diorite; while higher still come reddish-gray, quartz-veined, flinty sandstone and grit. Below the fork are cliffs of gray, slaty, porphyritic felsite, succeeded by red and green mottled, soft, friable slates or shales, with films of calcspar in the joints and small traces of hæmatite. Lower down, greenish and reddish flinty, fine-grained or compact, smooth, friable sandstone, and shaly or massive argillite, veined with quartz; and slates and massive argillite, extend to the telegraph road.

Brian Daly's Brook. The first rocks seen above the railway in Brian Daly's Brook,* are gray and reddish-gray sandstone, grit and conglomerate, largely composed of the debris of greenish and bluish-gray and reddish soft slates

* Trans. N. S. Inst. Nat. Sc., Vol. V., p. 199.

or argillites, like those of Baxter's Brook, which are in place, a little higher up, with flinty, splintery sandstone and more siliceous argillite. All these are overlain by the Medina belt of Marshy Hope valley. In the hill-range between Antigonish and Morristown, rocks of this group appear to be largely developed. At the head of a branch of North River, is a considerable breadth of gray and light-colored fragmental shales or slates, perhaps volcanic tuffs; and numerous similar outcrops in the neighboring branches, associated with syenite, greenish-gray, massive slate and quartzite or sandstone, and reddish-pink and gray, slaty felsite and quartzite. Lower down, and below the highest outcrops of Carboniferous limestone, are felsitic rocks and a beautiful red syenite passing into almost pure quartzite or quartz-porphyry. Silurian basin. Antigonish hills. North River.

In a small branch from the eastward, greenish, rusty, ferruginous and calcareous or dolomitic sandstone and shale, probably represent this group; the grit and conglomerate, near the school-house on the mountain, may also be doubtfully referred to it; while other outcrops in the neighborhood belong perhaps to the James River group. These rocks are well seen on the little brooks south of North River; on that to the north they comprise flinty, massive, fine sandstone, and greenish, silvery, smooth-bedded slates, with crystals of iron-pyrites, cut by dykes of syenite.

On the north branch of Right's River, about a mile above the railway bridge, the little brooks from the eastward show massive cliffs of greenish-gray and gracefully banded argillite and flinty, greatly jointed, rubbly, quartz-veined, pebbly sandstone and grit, like the rocks of Malignant Cove and Morristown. The land in the neighborhood is good and well cultivated. The slates are cut by dykes of gray, fine, epidotic, hæmatitic diorite, containing quartz-crystals in vugs. Right's River.

The Hallowell Grant slates have already been described.

Underlying the Carboniferous conglomerate in Livingstone Cove Brook, above the road to Ballantine Cove, is a bottle-green Pre-Carboniferous conglomerate with a band or vein of broadly crystalline calcspar or limestone; also, black slate, like that of McNeil's Brook and the shore at Georgeville, but less porcellanous, with shiny, structureless graphitic markings. Higher up, are black and gray, quartz-veined slates and soft, light-gray sandstone. Above the road in the brooks nearer Ballantine Cove, are outcrops of dark slates full of spots of pyrites, which is also in films between the layers, with many veins of white oily quartz. Livingstone Cove.

Bluish-gray flinty slate, probably of the James River group, occurs in some parts of the hill, and not far from the shore road.

On the shore, east of Georgeville, at the mouth of McPherson's Brook, the dark and light-gray, flinty rocks, seen higher up the brook, are Georgeville.

overlain by the bottle-green Pre-Carboniferous conglomerate of Livingstone Cove, which contains many pebbles of the slates and trap, and is well seen on the reefs at low water extending west to the next fish-house, where it is interstratified with very dark slate, succeeded farther west by a band of green conglomerate, fifteen feet wide. Quartz-veins run in the bedding of this conglomerate and irregularly in the dark slate. Both appear to skirt the coast outside a nucleus of James River rocks; the slate being softer than that of the James River group, rich in pyrites in films, crystals and spots, and holding lenticular calcareous and siliceous layers which may be fossiliferous.

Contact of Carboniferous and Cambro-Silurian rocks at Livingstone Cove.

On the shore at Livingstone Cove, the Carboniferous conglomerate is unconformably underlain by greenish and reddish slates, massive, fine, flinty sandstone and nut- and egg-conglomerate, intersected by greenish calcareous trap and porphyritic diorite, by quartz-veins, sometimes exceeding one foot in thickness, and by others of whitish calcspar, of one inch and less. The conglomerate, which is very much altered, is composed of pebbles of syenite, quartz, epidote and flinty argillite.

Veins.

Conglomerate.

To the westward, finer rocks predominate, as already stated.

The conglomerate at the point of next cove is redder, and besides pebbles of black slate and diorite, holds many of red syenite.

Up the next brook to westward, the cliffs nearest the shore are of light and dark gray flinty shales and flags, sometimes papery and pearly, which should yield fossils, and are underlain upstream by more flinty rocks with trap dykes.

Malignant Cove

The reddish and bottle-green very flinty conglomerate around Malignant Cove Pond, cut by dykes of dark diorite and reddish porphyry, is mixed with quartzose sandstone above the bridge on the shore road, and with slaty, coarse, conglomeratic grit and red slate, resembling some of the Upper Cambro-Silurian rocks of Marshy Hope. These form the walls of a gorge at the grist-mill, and near the saw-mill, are interstratified with greenish, flinty, quartzo-feldspathic rocks as flinty as those of James River, and sometimes so crystalline that they might at first sight be mistaken for porphyries and fragmental Louisburg breccia.

These strata are probably the same as those associated with limestone on Livingstone Brook, on the shore at the mouth of McPherson's Brook, Georgeville, and on McNeil's Brook, from which fossils were obtained; but whether certain beds do not belong to the upper, or Bear's Brook group, is not clear. They must be carefully distinguished, however, from the Carboniferous conglomerate higher up the brook. Below Blind Allan's shop are flinty James River rocks, cut by diorite.

Conglomerates of two periods of formation.

To this group probably belong, also, the peculiar rocks of the brook which crosses the Gulf road from the westward, immediately north of

Gulf road at Maryvale.

Maryvale—cream-colored, light-green and dark bluish-gray, rusty-weathering clay-slates, with a few hard bands of light-green sandstone, passing into compact quartzite and underlain by brownish slates, like those of Sunnybrae, the Keppoch, Baxter's Brook, and other places, associated with light-colored slates, containing white porphyritic spots, perhaps of volcanic origin, and cut by veins of a flinty mixture of opaque quartz and ankerite. Pits have here been dug in a brown, flinty friable rock, which contains films of calcspar, hæmatite and serpentine in the joints, and irregular veins of calcspar. Near the road, outcrops of massive, gray, flinty sandstone or quartzite, with a reddish tinge, are cut by red syenite, which contains very little hornblende. These rocks, perhaps, cross the road in the high knolls which bound the Carboniferous strata of Malignant Brook. **Mining operations at Maryvale.**

At the mouth of the little brook, about a mile east of McNeil's Brook, greenish, compact diorite is in contact with greatly altered fine grit and reddish conglomerate like that of Malignant Cove. **Volcanic and sedimentary rocks west of Malignant Cove.**

The first rocks seen above the shore road in McNeil's Brook are reddish porcellanous, fine friable argillite and greenish-gray flinty sandstone and argillite, cut by dykes of diorite, and interbedded with light-gray and whitish, somewhat micaceous sandstone and grit, often loose in texture. Higher up are bluish and blackish, very flinty, pearly, twisted slates, probably of the same formation as those of the shore at Georgeville, from which were obtained certain narrow, fine graphitized wavy markings, probably trails of annelids. **McNeil's Brook.** **Fossils.**

Just below the falls are red slates and greenish, earthy, massive concretionary sandstones, associated with dark hæmatitic traps and diorites. Dirty-greenish and reddish-gray soft argillites are, above the falls, cut by coarse, dark granular diorite; and higher still, greenish-gray, soft argillaceous shales show markings of fucoids and an obscure cystidean stem. Fine exposures occur on the branch of McNeil's Brook, at the fork of Angus Campbell's road, where the red calcareous slate and gray-greenish more flinty slate strongly resemble the rocks of Baxter's Brook; and the gray and greenish, ribanded, quartz-veined, flinty slate and grit, perhaps the highest beds of the James River group. Westward of McNeil's Brook, and some distance above the shore road, are several outcrops of hæmatite among ledges of greenish-gray flinty sandstone and shale, surrounded by red slates, and cut by the greenish-gray massive diorite and traps of the neighborhood. **Volcanic rocks.** **Fossils.**

At Angus Campbell's gate, red slates are mixed with syenite and trap; and in the small brook to the northward, whitish, flinty quartzite, with reddish and gray felsite and quartz-felsite. Lower down this brook, the quartzite overlies the red argillite of the little branch from

the left, and is overlain by cliffs of greenish and cream-colored, micaceous, more or less sandy shales, with flinty quartzose layers, spotted with ankerite, often mottled with red. At the Gulf road these slates are covered by Carboniferous sandstone; but in the next brook to the southward, again appear, mixed with breccias, reddish and greenish-gray compact quartz-felsite or syenite and dark-green diorite; underlain higher up by tuffs and rocks probably belonging to the James River group.

Cambro-Silurian rocks of the Gulf road

The soft rusty-weathering slates nearest the iron ore west of the Gulf road evidently belong to this group; but higher up are more flinty, ribanded slates, some also rusty and apparently interbedded with traps containing streaks and amygdules of opaline quartz and calcspar.

On the second brook crossing the Gulf road, north of Maryvale, similar calcareous and dolomitic, rusty-weathering slates are crowded with small crystals of iron-pyrites, interstratified with a greenish breccia or conglomerate, and with gray, massive and slaty, soft trap-like and fragmental rocks. Higher up are black, crumbling graphitic slates like those of Georgeville and McNeil's Brook. The resemblance to the Baxter's Brook rocks is more striking higher up the brook. They are underlain by another band of greenish conglomerate, formed apparently from the underlying James River group.

Black slates.

Doctor's Brook.

On the road up Doctor's Brook, south of the Hollow, red slates with interstratified breccias, flinty sandstones, and banded quartzites and hæmatite are well seen for some distance, and are then underlain by James River rocks, the contact with which is again seen not far from the Trunk road, on the road through the back settlement. Red slates are in place for seventy-three yards above the bridge over Doctor's Brook on this new road.

The Hollow.

Iron ore.

In all the little branches south of the Hollow, these red, concretionary slates, associated with tuffs and other volcanic materials, include many deposits of iron ore. On the Trunk road are outcrops of greenish-gray, soft, serpentinous, chloritic and calcareous slates, penetrated in all directions by threads of quartz.

South of the crossing of Doctor's Brook the James River rocks probably begin. On the branch east of the Trunk road the volcanic rocks nearest the main brook are succeeded upstream by greenish, flinty argillite, reddish and greenish mottled, hæmatitic and calcareous argillite, passing in places into pure hæmatite and limestone, and associated with bedded traps and with greenish, evenly-bedded argillaceous sandstones. These rocks strikingly resemble some of the Devonian strata of McAra's Brook; they extend to the deep bouldery valley, or Little Hollow, in which this brook takes its rise, and from which another begins to run to John and Andrew McDonald's. In the

Iron ore and limestone.

small brook west of McDonald's, traps are succeeded upstream by flinty rocks, veined with slaty, oolitic, hæmatitic limestone, which has been dug. Iron ore of Doctor's Brook.

A little higher, greenish, flinty, compact sandstone, in part thick-bedded and nearly white, reddish or brownish, micaceous, compact or fine-grained quartzite, sandstone and red slate, include a band of impure hæmatite one foot thick, apparently enclosed between layers of rusty, greenish-gray and cream-colored slate and sandstone, cut by diorite, trap, and large masses of white quartz.

On the west branch of Bailey's Brook are cliffs of greenish and gray flinty, splintery argillite and quartzite, containing calcspar and greatly jointed, which perhaps belong to this group, as well as the small indefinite exposures in the adjoining branch of Barney's River, which flows from Munro's clearing. Bailey's Brook. Barney's River.

On the branch of James River crossing Brown's Mountain road near the county line, the rocks are, perhaps, in part at least, of this group, consisting of gray flinty grit and porcellanous slate, whitish and cream-colored quartzite, cut by dykes of diorite. At New Strathglash and on the road to the post office at Brown's Mountain, the soft slates abound, but become more flinty near this post-office. Between the bridge at New Strathglash and Marshy Hope, light-gray and whitish flinty siliceous slates are cut by flesh-red syenite or nearly compact quartz-felsite, and succeeded lower down by reddish-gray fine sandstone grit, conglomerate and greenish, fine, brecciated argillite, probably belonging to the highest group. Similar rocks are also found at the head of Right's River. James River. Syenite. Right's River.

In the first little glen east of Marshy Hope railway station, whitish and reddish, flinty, quartz-veined, compact sandstone or quartzite is followed by red and green soft argillite, easily splitting into flags several feet square, sometimes almost replaced by quartz-veins; other neighboring brooks expose outcrops of sandstone, grit and slate. Marshy Hope.

In the brooks above the railway, east of James River, the contact of the Cambro-Silurian slates with the syenitic and dioritic rocks is well seen; the former are in part flaggy and thick-bedded, jointed, altered and arenaceous, splintery, with small quartz-veins.

The Marshy Hope Silurian strata form a narrow trough between hills of Cambro-Silurian rock. In the brook crossing the railway from the northward, east of the county-line, are the gray slates of Baxter's Brook. On Pushee's road no Silurian rocks appear, nor does the detritus indicate any in the fields south-west of Lindsay's old stage stables. The brooks from the north-east at the 30th mile-post and at the end of Glenbard road, expose greenish, flinty argillites, cut by dykes of felsite and quartz-felsite. On this road, near the railway, are Silurian basin of Marshy Hope.

outcrops of reddish-gray sandstone, green, soft slate, and flinty grit. On the brook from the road, at Hector Grant's, are greenish and reddish, soft, splintery shales, with films of hæmatite in the joints, and bands of flinty, quartz-veined, compact and fine-grained, reddish-gray sandstone, and grit, apparently belonging to the upper group; and among them an outcrop of bright-green, soft, black-spotted trap. Below the trap, the cliffs display reddish-gray, splintery sandstone and soft slate, veined and blotched with quartz and calcspar. The boundary between the two groups, however, is not distinct; and the same may be said of the rocks at the head of Bear's and Bailey's Brooks.

Boundary obscure between groups 2 and 3.

The hill in the rear of Brian Daly's house, Marshy Hope school and post-office, probably marks the limit of the Silurian rocks, the road being thus approximately their southern boundary; while the hill on the north, out of which these rocks extend at least to the first bridge, follows about fifty yards from the railway nearly to Oulton's road. At the 27th mile-post, Cambro-Silurian strata are probably not more than 150 yards south of, if they do not come into, the road, and the closing of the glen, near Rory Grant's, seems to indicate the end of the basin.

Pleasant Valley

Although most of the Cambro-Silurian rocks in the neighborhood of Pleasant Valley, seem to belong to the lowest group, yet near the top of the Carboniferous valley are soft, greenish, calc-veined slates, perhaps of the middle group.

Keppoch.

On the Keppoch, the most easterly outcrops of this group, seen in a little brook immediately west of St. Joseph's Lake, succeed a reddish and grey, porphyritic felsite, which underlies Carboniferous rocks. They consist of brown or chocolate-red argillite, with a tinge of green, with harder layers of sandstone, cut by diorite dykes. Upstream are blocks of fine grit, perhaps Carboniferous. On the roads west of this brook, the green slate and gray flinty sandstone underlying the Carboniferous conglomerate and limestone, are as usual cut by dykes and apparently associated with fragmental felsites, like those to the southward, which have been classified as Pre-Cambrian.

Beaver River.

On Beaver River, above McLean's mill, greenish, smooth-bedded, splintery slates, underlie Carboniferous conglomerate, and are cut by dykes of greenish, coarse diorite. In Hartshorn Brook, greenish argillites, containing blotches of white calcspar and of a mixture of quartz and calcspar, sometimes three inches thick, have a cleavage oblique to the bedding but with the same strike, and are associated with a breccia or conglomerate composed entirely of fragments of soft green slates: this may either be on the line of a fault or be derived from fragments of the James River group. A similar breccia is again seen on the railway near Barney's River station, in contact with intrusive rocks. Outcrops occur at intervals up to the head of this brook and also on

the adjoining brooks; they are always somewhat massive, flinty, and seldom show the dip.

Higher up the Beaver River, near McLean's road, are cliffs of gray and greenish, siliceous slate, more or less splintery, somewhat pearly, in contact with greenish, porphyritic felsite and quartz-felsite, containing hornblende, iron-pyrites and epidote, and giving the slates at the contact a flinty, porcellanous aspect and prismatic cleavage, which breaks them into long pieces at right angles to the bedding. This outcrop is on the right branch above the fork. The cliffs of the left branch show gray, bluish-gray and greenish, pearly, evenly-bedded, siliceous slates, with a tinge of red, associated with sandstone and containing threads and irregular blotches of quartz. On the road near McLean's, the felsitic and dioritic rocks, sometimes nearly compact, contain also quartz and calcspar, massive and fragmental, some fragments being one inch in diameter.

On Coillteach Brook the boundary between the greenish, pearly, siliceous slates and the felsites to the southward, is along a green, fine diorite, gray granular quartz-felsite and gray, porphyritic felsite, seen only at the contact. Quartz veins.

The slates are full of white quartz, generally in the bedding, and in some places nearly replaced by it: large masses of barren quartz appear also in the felsite; this felsite, which has an obscure bedding, and seems to pass into the slate, is in part pebbly or brecciated, and might belong to either group, although lower down it has rather the appearance of an intrusive rock.

Nearly all the Cambro-Silurian rocks on the various branches of Barney's River, appear to belong to the upper or Bear's Brook group. Barney's River.

The strata of Rory Grant's Brook, apparently belong largely to the middle division, although the grit and sandstone of the hill and the grit and conglomerate at the head of the brook, resembling those of Malignant Cove, are perhaps newer.

On McIver Brook and on the middle branch of Barney's River, the rocks immediately beneath the Medina are apparently of the Baxter's Brook group; and if so, indicate its want of conformity with the Silurian. Contact with Silurian.

Above the carding-mill, on the river, they consist of greenish, reddish and whitish grit and pyritous sandstone, associated with granular and porphyritic felsite and diorite, bright red and green, mottled, fragmental rocks, and also with slates resembling those of Baxter's Brook. On the branch flowing from the new road near Irving's, the slates are cut by diorite and by greenish and reddish, soft, chloritic traps. Near the confluence of this brook, Barney's River shows greenish and gray, somewhat pearly slates and whitish, pyritous grit, overlain by Medina sandstone.

At their contact with the syenitic rocks of the mountain toward Munro's, the slates do not seem to be more porcellanous than usual.

Piedmont Cambro-Silurian rocks.

Those of the hill south of Piedmont Valley, belong in part to the Baxter's Brook group, and are cut by masses of syenite and other intrusive rock. On the southern slope of the hill, Medina sandstone is underlain by reddish grit of the higher group; underlain in turn by reddish, soft slates and flinty, splintery slates, like those of Glenbard; by gray and greenish slates, and on the northern slope, by greenish and reddish banded slates.

Avondale.

On the top of the hill, near Avondale railway station, at John McLeod's house, red syenite is in contact with greenish, Cambro-Silurian slate, while nearer the station and also toward Wm. Murray's house, greenish-gray, earthy, Silurian sandstone and slate are in place.

On the little brook, thirty yards west of Piedmont station, brownish, soft Carboniferous sandstones are underlain by greenish slates, seamed with a network of dark veins, greenish and gray, calcareous, massive sandstone and slate, and reddish and greenish flinty argillite. On the hills, which are for the most part cleared, fine outcrops of all these rocks can be easily examined. On the Wagner road, sandstone is in contact with greenish, quartz-veined, almost papery, Baxter's Brook slate.

Between the road and the top of the hill northward, mottled red and green, soft, pearly slates, veined with quartz, resemble certain slates seen on Sutherland's River. On the mountain farther north, these are cut by reddish and gray, flinty, compact felsite and quartz-felsite, holding small crystals of pyrites and passing into reddish fine syenite. Nearer Piedmont greenish-gray and reddish ribanded slates, cut by dykes of soft, greenish-black diorite, cross the road, succeeded by dark bluish-gray and reddish flinty slates, compact or fine-grained, mottled sandstone or quartzite and fine grit. At the head of the Ohio settlement, the gray and greenish-gray flinty slates of Callahan Brook, already referred to, are perhaps Cambro-Silurian. In the minute quartz-veins of the gorge, gold is reported to have been discovered.

West River of Antigonish.

Gold (?)

Black Brook, St. Mary's.

Similar slates, found among the felsites on the road to Black Brook, are probably also of the same age, as well as the small outliers of reddish sandstone of the upper Black Brook Lake, and the dark slate of the lake near Gunn's.

On the shore of the upper lake, reddish sandstone, grit and conglomerate, which may belong to the upper group, are almost certainly in place; and from the abundance of blocks of sandstone and argillite along the road, it may be inferred that such rocks occur there also, although felsitic rocks prevail everywhere in the neighborhood.

Black Brook, not far above the St. Mary's road, cuts through bluish-

gray, fine, micaceous, coherent slate, doubtfully Cambro-Silurian, resting on reddish and gray, flinty, compact quartz-felsite, at contact with which no metamorphism is noticeable. It contains fucoids and passes into fine sandstone, but is essentially argillaceous and so cleaved that the dip is obscured. At the lower part of the outcrop it is dirty-green, crumbly and very rusty, or papery and dark bluish-gray, with about ten feet of gray calcareous argillite full of minute, hard crystals, possibly produced by its contact with the quartz-felsite. The purple, coherent argillites, found higher up the Black Brook, are perhaps also Cambro-Silurian, although they may be Devonian and a continuation of those of Lochaber. **Contact of Cambro-Silurian slates with felsites.**

The red, greenish and gray slates and conglomerate of Campbell Brook, Green Brook and the Garden of Eden, are also perhaps newer than Cambro-Silurian. On Campbell Brook the conglomerate of the west branch is somewhat friable, massive and jointed, with minute veins of specular iron, and associated with marl and grit. It contains pebbles of the syenite, felsite and similar rocks upon which it rests, but also of red and whitish, flinty sandstone and grit. On Garden River the slates above Fraser's are bluish and greenish-gray, flinty and pyritous, but are followed upstream by red, soft slates. **East River of St. Mary's.**

On the west side of Eden Lake, irregular areas of Baxter's Brook slates, presenting considerable variety, are cut by dykes of felsite, but not more metamorphosed than usual at a distance of three feet from the contact; so that the general great metamorphism of these strata is clearly not dependent on these intrusions. **Eden Lake.**

On the Copper Mine Brook, above Eden Lake, are large outcrops of these rocks, but whether they are contemporaneous with or newer than the neighboring schists and fragmental felsites, has not yet been determined.

Above the syenite and Silurian rocks of the lower part of the little brook which crosses the road between Eden Lake and Kerrowgare, about a mile east of the East River of Pictou, appear good outcrops of gray and greenish-gray, massive, rubbly argillite, ferruginous, calcareous and probably dolomitic, cut by dykes of greenish, fine diorite. Higher up are ledges of flinty, rusty-weathering quartzite or grit, overlain by gray, sandy, pyritous, fine slates, often very dark, containing veins of limonite which have been worked, but are apparently of no value; and higher still, reddish and greenish flinty argillite and fine sandstone. **Head of the East River of Pictou.** **Iron ore.**

Greenish and reddish argillite occur in the East River below Smith Lake, at its confluence with a little brook from the eastward, in contact with red syenite; while below the confluence are outcrops of reddish and greenish ribanded slate and sandstone.

Sunnybrae. Immediately above Sunnybrae bridge, on the north bank of the East River of Pictou, black Clinton slate is in place; one hundred and fifty yards upstream is an outcrop of Medina sandstone; and one hundred yards higher, reddish, flinty, compact, Cambro-Silurian quartzite, full of films of specular iron. (Iron ore.) At the mouth of the brook from the church and school, the fine sandstone or quartzite, greenish and gray slate, coarse grit and reddish and greenish soft argillites, in stripes or bands, resemble the rocks at Dunbar's on the opposite side of the river, in which obscure brachiopods, were found, and also those of Doctor's Brook. (Fossils.) At the church are Baxter's Brook slates; on the next brook to the eastward, blackish and gray, rusty-weathering, rubbly slates, in indefinite thick beds, with light and dark-greenish trap and porphyritic and fragmental felsite and diorite, blotched with epidote, quartz, and films of specular iron. (Volcanic rocks. Iron ore.)

The detritus in the road above Sunnybrae is Cambro-Silurian as far as the church; the associated volcanic rocks are apparently not newer: they require no special mention and their extent will be seen from the map. They come from beneath Silurian strata in Thompson Brook, in a belt of no great width, above which are greenish, siliceous slates, succeeded again by Silurian. (Thompson Brook.) To their greater hardness are due cascades of considerable beauty in Blanchard Brook, below the cliffs of Silurian and Cambro-Silurian at the mill-pond; these rocks consist of reddish, purplish and greenish, porphyritic, flinty felsite and breccia, and include aluminous shales, containing much calcspar and specked with micaceous iron ore. (Blanchard Brook. Iron ore.) The fragments of the breccia are of every size, but usually smaller than a pea; the dip is obscure. Silurian rocks occur higher up, with nearly horizontal dip, succeeded again by bright-green, fragmentary and nearly compact, soft breccias, with films of calcspar and serpentine in the joints. (Silurian rocks.)

On the road from Sunnybrae church to Blanchard, Cambro-Silurian slates give place to massive, green diorite, to flinty, gray and reddish porphyritic felsite, to trap and to reddish, fragmental slates, which occupy most of the road to the McInnes settlement near Sutherland Lake, from the lake to the Blanchard road and thence southward as shown on the map.

McLellan's Mountain. The upper and middle groups can also be separated between Bridgeville and Sunnybrae, Springville and McLellan's Mountain; but the tracing of the boundary requires further surveys to be made.

French River. The areas on the east branch of French River, at the Blue Mountain church and elsewhere in the vicinity, require no special description. On the branch of French River flowing from Robert McLeod's, gray and greenish slates are associated with fine, quartz-veined sandstone. On the river above the confluence of this brook, are fine exposures of

greenish, soft, ribanded slates and sandstones, cut by dykes of porphyritic diorite and felsite, which for a few inches from the contact render the slates porcellanous.

The rocks first seen on Sutherland's River,* beneath the Carboniferous strata of the Pictou coal-field,† belong to this group; greenish, flinty argillites or slates, resembling those of Beaver River are mixed with dark-green trap in the gorge with a succession of fine falls at Park's mills, where the cliffs rise to a height of fifty feet. The cliffs above the lowest fall are composed of greenish, siliceous slate, blotched with quartz. Above the bridge, however, large outcrops of dark and light-green trap and reddish-gray, hæmatitic, flinty, compact felsite, quartz-felsite and red soft argillite, in shaly layers, are succeeded by reddish-gray, fine, massive, jointed Upper Cambro-Silurian conglomerate and grit, and continue to the bridge on the St. Mary's road, where they are overlain by Medina and higher strata, remarkably rich in fossils.

Pre-Carboniferous rocks of the Pictou coal-field.

Park's mills.

Volcanic rocks.

Upper Cambro-Silurian.

Medina.

After a long interval of Silurian slates, greenish, smooth-bedded, somewhat pearly, wrinkled and papery, coherent slates, resembling the slates of the upper part of Vamey's Brook, and interrupted by masses of greenish, fine, pyritous diorite, containing much quartz and epidote, extend far up the stream, which here forms several cascades and falls. The rocks seen near Alma mills, at the crossing of the railway bridge, are somewhat similar, and among them is a greenish breccia like that of Hartshorn Brook; but Sir J. W. Dawson reports the discovery of Devonian plants; so that the strata of this brook are, no doubt, newer.

Devonian rocks of the Middle River of Pictou

3. *Upper Cambro-Silurian Rocks or Reddish-gray Sandstone, Grit and Conglomerate of Bear's Brook.*—Some of the Cambro-Silurian strata of the Morristown Hills and of Livingstone and Malignant Coves may, as above stated, belong to this group, which is, however, most largely developed on the various branches of Barney's and French Rivers.

On the east branch of Barney's River, east of the road at the railway station, rusty-weathering Silurian slates are underlain by reddish-gray, very flinty conglomerates or quartzites, associated with gray, red-spotted, compact, quartz-veined, porphyritic felsite, as seen near the mouth of Bear's Brook.

Barney's River.

Up this brook the volcanic rocks are succeeded by dirty-green, greenish-gray and dark-bluish, splintery, striped, slates; succeeded again by felsite, in part obscurely granular; and, still higher, by greenish and gray flinty argillites and compact sandstone, like those of Baxter's Brook. Fine outcrops of flinty slate, compact quartzite, sandstone and conglomerate, cut by felsites, soft calcareous traps and

Beaver's Brook.

* Trans. N. S. Inst. Nat. Sc. Vol. III., p. 69, and Vol. IV., p. 463.
† Geological Survey Report for 1886-89, p. 6.

Volcanic rocks. fine porphyritic diorite are seen in the brook and its branches, the sedimentary rocks being slightly altered at the contact. At the falls, in the main branch are greenish-gray argillite and sandstone, sometimes speckled red; at the upper falls of forty feet, greenish fine diorite, slate and flinty felsite are associated. At Charles W. Oulton's, near the head of the brook, slate, flinty, quartz-veined sandstone and grit are cut by a mass of gray granular syenite and diorite.

The south branch of Bear's Brook presents abrupt cliffs of greenish-gray, evenly bedded, splintery, siliceous argillite, with calcareous bands, full of calcspar veins, passing into impure crystalline limestone, (Limestone.) cut by gray, greenish, bluish-gray and blackish, fine, pyritous diorite or obscure granite, the felspar being in whitish distinct grains. The alteration along the dykes is not great. Higher up, and also at the head of the east branch of Barney's River, the argillites are apparently overlain by reddish and greenish fine sandstone, massive, thick-bedded or shaly. In the adjoining brooks, reddish-gray fine grits and argillites are met with, and on the railway, mixed with reddish and gray coarse syenite, quartz-felsite and a breccia like that of Hartshorn Brook. Porphyritic felsite and diorite, and flinty, greenish porcellanous rocks are found near the mouth of Bear's Brook.

Contact with Silurian. On the old post road opposite, reddish fine conglomerate and sandstone, full of reticulating veins of quartz, are overlain by greenish, tough, flinty, nearly compact Medina sandstone, that has been traced both up and down Barney's River.

Bailey's Brook. At upper Bailey's Brook, a belt of reddish and bluish-gray coherent grit and of flinty, quartz-veined sandstone and nut-conglomerate follows the old mountain road, underlying Silurian fossiliferous strata, and underlain in turn by the flinty rocks of James River, which can be traced to a track between the head of Keefe's Brook and William (Keefe's Brook.) McDonald's road to the northward.

Below the road in Keefe's Brook, reddish-gray fine grit is associated with greenish-gray, somewhat resinous, ribanded, pearly slate, like that of Baxter's Brook. Grit and sandstone, with minute quartz-veins, also occur on the west branch of Bailey's Brook, on Brown's Mountain road, near the county-line, and at the head of the branches of James River in the vicinity.

Barney's River station. The crests and precipices of the hills east* of Barney's River railway station show sparkling quartzose, pebbly grits, underlying the Silurian rocks of the valley, the contact being well seen in the triangle formed by the railway, the telegraph road, and the road down the (Contact with Silurian.) middle branch of Barney's River.

*Transactions N. S. Inst. Nat. Sc., Vol. V., p. 195.

Near the head of Bruce Brook they are associated with gray, reddish and greenish porphyritic breccia, and granular, fine diorite. At the east end of the old Crockett road, grits and quartzites are in place, overlain toward the west end by Silurian strata. Equally good exposures of conglomerate and coarse grit, cut by veins of quartz and blotched with calcspar, present themselves on the west branch of Barney's River, above the bridge at Robinson's, surrounded by and underlying Silurian strata; and also in the hills south-east and east of Kenzieville, containing pebbles of syenite and slate, and associated with red porphyritic felsite or breccia, and soft, purple amygdaloid. The porphyry first seen on the large branch which enters at Stalker's bridge, is succeeded by reddish-gray sandstone, grit, breccia, and fine, dark hornblende-rock or diorite; by flinty, coarse, pebbly grit and conglomerate, and greenish-gray, fine, quartz-veined sandstone; and again, above Alexander Bannerman's, by light-gray soft trap, red compact porphyry and flinty diorite. On the western branch a greenish slate, like that of Beaver River, and a red argillite, like that of McNeil's Brook, both belong apparently to the Baxter's Brook group. Bruce Brook. West Branch of Barney's River.

In the small brook from the westward at Sutherland's, grit and nut- and egg-conglomerate are again exposed; the pebbles include a red and purple porphyry, like that of the river, and some of the altered grits bear a strong resemblance to the fragmental felsites. Conglomerate.

In the little brooks running north into Piedmont valley, east of the railway station, many large blocks of reddish-gray, flinty, quartz-veined quartzite, grit, conglomerate and felsite probably indicate this group. On the top of the hill, behind the station, are knobs of quartzite and grit, overlain toward French River by Medina strata. Grit and conglomerate, Baxter's Brook slates and syenite occupy the western end of the hill. Their contact with the Silurian and Carboniferous rocks has been carefully traced. In the east branch of French River, above the Piedmont road, a cliff of Cambro-Silurian quartzite and reddish grit protrudes from the bank on the north side, and is immediately overlain by Clinton slates, the Medina being here wanting. There is no evidence of faulting, and the black slates seem to be nearly horizontal. The flinty, whitish quartzites and gray and rusty quartz-veined grit seen east of the school at Beaver Lake, and on some of the brooks north of the East River of Pictou, are doubtfully Cambro-Silurian. Piedmont. Contact with Silurian and Carboniferous. Clinton resting directly on Cambro-Silurian. East River of Pictou.

In contact with Medina sandstone, in the east branch of French River, are greenish coarse grits, with crystals of pyrites, passing into egg-conglomerate, which holds pebbles of the red Cambro-Silurian argillite of the mountains. On the next brook to the westward, Silurian rocks are underlain by grit, in turn succeeded by gray, greenish and reddish slates. East branch of French River.

Near Paul and Alpine Grant's, south of Glenshee, similar strata are penetrated by fine porphyritic trap, a flinty conglomerate, containing pebbles as large as cocoanuts, of reddish porphyry and other felsites. Near Glenshee, McGrath's Mountain, and in the country to the southward, reddish conglomerate and grit, in thick beds or massive, are overlain by Silurian sandstone. Greenish slate and quartzite are occasionally present, but most of the beds are coarse. In the McCulloch settlement, a conglomerate containing large pebbles and even boulders, crossed by numerous small veins of quartz, is cut by reddish and greenish compact and granular syenite, porphyry, pyritous diorite and amygdaloid. Wallace Brook displays traps interbedded with conglomerates, and underlain by a broad belt of greenish and gray slate, probably of the middle group, and by the schists described as Pre-Cambrian, the latter being well exposed and full of quartz-veins. In the neighborhood of Meiklefield post-office are outcrops of the reddish grit and trap of Wallace Brook, in contact with Silurian rocks.

Contact with Silurian and Pre-Cambrian.

The reddish flinty grit above Park's mills in Sutherland's River, on the outskirts of the Pictou coal-field, has been already described (page 33 P) as belonging to this group, and its distribution and relations to the strata above and below also indicated.

E. Silurian.

Extent.

Rocks of this system lie in the limited areas mentioned on page 6 P, in valleys or among hills composed of the strata already described; and pass beneath Devonian, Carboniferous or Permian strata. They occupy only a small portion of the region indicated by Sir J. W. Dawson,* and colored Silurian on his geological map; but more nearly that as limited in the Supplement, page 76. For details concerning them, the publications of the list given in Acadian Geology, pp. 10 to 12, may be consulted, particularly the paper by Dr. Honeyman on "The Geology of Arisaig," in the Quarterly Journal of the Geological Society of London, Vol. XX., p. 33. These strata are everywhere crowded with marine fossils, which range, as stated in this paper on the authority of Mr. Salter, from Medina to Lower Helderberg, but subsequently supposed by Dr. Honeyman to range as low as the Hudson River.† A large collection, made last summer at Arisaig and Lochaber by Mr. T. C. Weston, has been given to Mr. Ami for examination, and will be placed in the Geological Survey museum, with other fossils previously obtained by Dr. Honeyman and Mr. Weston. Others, the result of many years' collecting by Dr. Honeyman, are exhibited in the provincial museum at Halifax.

Range of fossils

* Acadian Geology, p. 560.

† Trans. N.S. Inst. Nat. Sc., Vol. VI., pp. 309 and 319, and elsewhere.

T. C. WESTON, PHOTO., 187[illegible]

IVES-PROCESS: G. E. DESBARATS, MONTREAL.

SECTION AT STONEHOUSE BROOK, ARISAIG COAST, NOVA SCOTIA.

SHOWING TRAP DYKE CUTTING UPPER BEDS OF LOWER HELDERBERG.

Classification.

The following groups are so distinct that they can usually be recognized apart from their fossils:

E 1.	Medina,	Division A	of Dr. Honeyman.	
E 2.	Lower Clinton,	"	B	"
	Upper Clinton,	"	B′	"
E 3.	Niagara.	"	C	"
E 6.	Lower Helderberg,	"	D	"

Arisaig section

An approximate section of these rocks underlying Carboniferous conglomerate and trap on the Gulf shore between McAra's Brook and Arisaig pier, where they are most accessible and well exposed, will serve to show their composition and general characters. The direction of the shore is about 53°.

SECTION OF SILURIAN ROCKS AT ARISAIG IN DESCENDING ORDER.

	FEET.	INCHES	
E 6. LOWER HELDERBERG.			
1. Reddish and purplish altered flags with bright emerald-green blotches and layers; more or less argillaceous, flinty and splintery, containing thin calcareous layers full of blackened shells. The red and purple beds greatly predominate; they end about fifteen yards north-east of McPherson's Brook. Dip 166° < 46°	100	0	Red rocks. McPherson's Brook.
2. Dirty-green, greenish and gray quartz-veined flags and shales, holding encrinites and shells in abundance. Seen in Stonehouse Brook as well as on the shore. Veins cut across the bedding and are sometimes three inches thick. Perhaps unconformable to 1. Dip 207° < 41°. End at the mouth of Joseph McDonald's Brook	310	0	Stonehouse Brook. Joseph McDonald's Brook.
3. Dirty-greenish rocks finely ripple-marked, full of fossils. Dip 203° < 32°	205	0	
4. Dirty-green and gray, rubbly or prismatic, rusty-weathering argillo-arenaceous flags. The bottom of Dr. Honeyman's Group D.—Lower Helderberg or Ludlow Tilestone. (Quarterly Journal of the Geological Society of London, 1864.) Dip 194° < 38°	393	0	
5. Indian-red crumbly prismatic marl, with a thin band of gray limestone full of fossils. In the upper part mixed with bright-green patches and full of calcareous nodules, like the rock of Indian Brook, Cape George. The green of the beds immediately overlying is brighter than usual, and the whole mass is more or less concretionary and nodular. This is Dr. Honeyman's "red stratum," Op. cit. p. 336, and is also described in Mr.			Red stratum.

		Feet.	Inches.
	Weston's section and shown in View No. 6.* Dip 169° < 34°. It has been traced more than half a mile eastward of the Trunk road........................	30	0
	E 3. NIAGARA.		
	6. Greenish argillaceous and calcareous rocks, with thin bands of limestone. Dip 169° < 37°. Ends at the mouth of a little brook..................................	95	0
	7. Dirty-greenish and gray, more argillaceous and crumbly, with numerous layers of gray limestone remarkably rich in fossils. Dip 171° < 26° — 44°................	328	0
	8. Light-gray more or less argillaceous rock. Dip 189° < 44° — 66°..	128	0
	9. Dark-gray and bluish-gray argillites, breaking into knife and needle-shaped fragments; hard flaggy bands and a few small layers of limestone rich in fossils. The proportion of coherent bands to the great mass of the argillites is, however, very small. Dip 177° < 48°....	50	0
Cone-in-cone.	10. Dark shales in cliffs; very few hard bands. A fine concretionary mass of cone-in-cone limestone, four feet in diameter and full of shells, lies in the shales, which are also rich in fossils. Large spherical concretions, probably also derived from these beds, lie on the beach. Dip 176° < 38°..	200	0
McAdam's Brook.	11. Dark shales, as in 10. To the mouth of McAdam's Brook, where the dip is 164° < 36°..................	128	0
Fault?	12. Dark shales, like 10, but with more hard bands. Dip 164° < 36°. Here the dip turns to 202° < 42°, but probably indicates only an unimportant local undulation, for a short distance further it is 165° < 37°.....	58	0
Veins.	13. Dirty-greenish and gray, prismatic, somewhat flinty calcareous argillaceous rocks, with occasional veins of quartz and calcspar and thin layers of fossiliferous limestone. Dip 168° < 36°. Reefs and low cliffs......	175	0
Fault?	14. Dark-gray and greenish argillite, jointed or broken into small pieces, and containing large calcareous concretionary masses and beds very rich in fossils. In a distance of fifteen chains on the shore, the dip changes from 168° < 37° to 134° < 23° back to 153° < 27°, and, ten chains farther east, to 189° < 40°....................	86	0
	15. Dark-gray, rusty-weathering shales, not unlike those of Barney's River, containing thin concretionary layers of light-gray fossiliferous limestone. In nearly continuous cliffs and reefs, but thickness obscure owing to changes in the dip. Probably not more than........ Dip at the base 176° < 27°.	45	0

*One of a series of 21 views, taken by Mr. T. C. Weston, in 1873, copies of which are in the Geol. Survey museum.

	FEET.	INCHES.	
E 2. Upper Clinton.			
16. Light-green shales, with thicker and more numerous hard bands, which are sandstones rather than limestones and not so rich in fossils. Some of the layers have a brownish tinge. Forty yards west of the contact with 15, a small brook (Smith Brook) falls over the cliff. These form apparently the highest beds of Dr. Honeyman's Group B′ (Upper Clinton). Geol. Jour., 1864, page 336. A small fault or disturbance separates 15 from 16, the dip of the first green rocks being steeply west, while at a distance of five yards to the eastward they, dip 174° < 11°. This fault is probably an upthrow on the east side, by which the red band representing the iron ore, and seen in Smith Brook, is concealed on the shore....	32	0	Fault. Iron ore.
17. Green shales with flaggy layers of light-gray, fine and nearly compact flinty sandstone, seldom six inches thick. In the sandstone are threads of quartz and blotches of calcspar in the shales, but the general absence of veins is remarkable. At the top an undulation makes the dip 212° < 11°, after which it is 179° < 19°....	53	0	Veins.
18. Green shales, like 17, with some of the layers of flinty sandstone one foot thick. Dip 181° < 20°, but the lower beds are greatly contorted, as if for an upthrow fault on the east side....	63	0	
19. East of this point the shore rocks are greatly disturbed, and 50 yards east dip 113° < 28°; at 45 yards further 16° < 12°; at 40 yards further, 303° < 29°, flattening a short distance further east to < 6°, and turning to 254° < 8° at 31 yards further; 80 yards beyond, to 219° < 23°, while at 334 yards from the first mentioned disturbance, the dip is 156° < 50°, and at the mouth of Arisaig Brook, 176° < 37°. In the first part of this interval, the B′ green shales and flags—sandy, micaceous and very evenly bedded—are on the shore, with a few thin brown layers, succeeded further east by dark-gray B crumbling argillite, with occasional bands of light-gray flinty sandstone, like the strata of 15....	—	—	Change of dip. Arisaig Brook.
E 2. Lower Clinton.			
20. Dark-gray or blackish, rusty-weathering, crumbly, papery argillites, with scarcely a trace of a hard band, seen in cliffs near the mouth of Arisaig Brook. The relation of these rocks to 18 is not clear: they may underlie them either directly or after a gap. North-east of the mouth of Arisaig Brook, they are exposed, for about 250 yards, in descending order. The shore then			

	FEET.	INCHES.
runs on the strike. The thickness of B rocks here exposed—the dip rising to < 49° near the bottom—is...	345	0
21. North-east of the little brook and boat-landing, where this section ends, the dip changes to 96° < 17°, then to 16° < 45°; at 235 yards to 186°, and 30 yards further to 79° steeply. No estimate can consequently be here made of the thickness. At the lobster factory, the dip is 98° < 35°, and between this point and the flinty quartz-felsites of Arisaig pier, only obscure outcrops occur of dark, crumbly, papery shales, above high water, and of the following:—		

Arisaig pier.

E 1. MEDINA.

22. Dirty-greenish and gray, rusty-weathering, argillaceous, usually more or less massive, flinty sandstone, obscurely seen at the base of Arisaig pier, but well exposed to the eastward, and variously estimated at 163 and 201 feet. Dr. Honeyman's Division A, or Medina	182	0
Total thickness	3006	0

Mr. Weston's section.

The following ascending section, measured by Mr. Weston in Joseph McDonald's Cove, shows in more detail the beds immediately underlying No. 5 of the preceding section, which contains Nos. 17 to 21 of Mr. Weston's section.

	FEET.	INCHES.
1. Olive-green even-bedded argillaceous shales, with bands of a similar rock, but much harder, containing more lime and silica and breaking with a conchoidal fracture	3	3
2. Green even-bedded argillite, with fucoids	1	4
3. Calcareous sandstone, with *Favosites*	0	3
4. Green argillaceous shale	0	3
5. Compact argillaceous limestone, breaking with an uneven fracture and holding *Rhynchonella* and other obscure fossils	0	5
6. Green argillaceous shale, with fucoids and *Rhynchonella*	0	4
7. Green argillaceous shale, interstratified with bands of calcareous sandstone and thin beds of limestone holding *Rhynchonella*, *Modiolopsis* and other fossils..	5	0
8. Green argillaceous shale, with thin beds of light-gray limestone holding fragments of encrinites, *Rhynchonella* and *Modiolopsis*	5	0
9. Hard, argillaceous, calcareous shale, with splintery fracture	3	0
10. Calcareous shale with thin bands of limestone crowded with *Rhynchonella*, *Modiolopsis* and other forms....	2	0

T. C WESTON, PHOTO., 1873.

IVES-PROCESS; G. E. DESBARATS MONTREAL.

SECTION IN JOSEPH McDONALD'S COVE, ARISAIG COAST, NOVA SCOTIA.

SHOWING JUNCTION OF NIAGARA AND LOWER HELDERBERG.

	FEET.	INCHES.
11. Green argillaceous shale, with bands of calcareo-argillaceous sandstone containing a small coral..........	1	2
12. Light-gray limestone....................................	0	2
13. Green argillaceous shale, with bands of calcareous sandstone and limestone, holding *Favosites*, *Rhynchonella* and other fossils..................................	3	0
14. Light-gray limestone with *Rhynchonella* and fragments of other fossils..................................	3	0
15. Light-gray limestone with *Rhynchonella*, *Modiolopsis* and encrinites. These beds also hold black nodules made up in some instances of fragments of *Rhynchonella* and other brachiopods, an analysis of which shows them to be phosphatic..............	2	0
16. Green argillaceous shale with a few thin bands of limestone holding phosphatic nodules as above; also fossils of the genus *Tentaculites*, *Homalonotus Dawsoni* and other forms..............................	13	0
17. Green and red even-bedded shales holding *Modiolopsis*, *Rhynchonella* and other fossils..................	2	0
18. Maroon-coloured argillaceous limestone, with splintery fracture, holding nodules of light drab-coloured limestone....................................	12	0
19. A limestone similar to the preceding, but highly charged with elongated nodules, having a position transverse to the bedding.............................	1	0
20. Maroon-coloured argillaceous limestone, as above......	5	0
21. Limestone similar to the preceding, but of a more shaly nature, and having numerous light-green patches..	10	0
22. Green argillaceous shale and limestone, resembling the above and holding obscure fossils, among which are a *Lingula* and a *Discina*........................	15	0
Total thickness....................	88	2

Phosphatic nodules.

The structure at Arisaig is a syncline, six miles long and one mile and a half wide, extending from McAra's Brook to McNeil's Brook, bounded on the south by the fault indicated by the Cambro-Silurian escarpment of the south side of the Hollow; and on the north by the Pre-Cambrian series of Doctor's Brook, Frenchman's Barn and Arisaig pier; overlain to the westward by Devonian and Lower Carboniferous strata. A block less than a mile wide seems to have been thrown up by two faults running north and south between Smith Brook and a point east of the Trunk road. The bottom of the Silurian system is well defined by the presence of the two lowest groups, the Medina sandstone resisting disintegration and rising high on the slopes of hills composed of Cambro-Silurian rock, while the Lower Clinton black slates with lingula nodules, although deeply denuded in the valleys, are found in cliffs flanking the rivers. Some particulars concerning the different groups in the areas above mentioned will now be given.

Arisaig synclinal.

Faults.

Contact with Pre-Cambrian, Devonian and Carboniferous.

E 1. Medina.

Extent. The Medina is apparently present in all the areas except that of Cape George. At Arisaig it is exhibited in a narrow belt from the pier eastward to Beech Hill Cove. In Doctor's Brook, at its contact with the felsites, it consists of dirty-greenish and more or less argillaceous sandstone with flinty siliceous layers. From the cove west of this brook many of Mr. Weston's fossils were obtained.

Fossils.

Vamey's Brook. The Silurian strata of Vamey's Brook are probably Medina, but are of limited extent, and although fossils are abundant, none were collected.

Marshy Hope basin. Resting upon Cambro-Silurian grits, along the railway in Marshy Hope valley, is a long narrow trough of gray and of greenish, rusty-weathering Silurian sandstone well displayed in the little brook east of Lindsay's old stage-stables, where the former consist of gray flinty pea-conglomerate with beautifully mottled, pink, brown and yellow porphyritic, compact and fragmental felsite and quartz-felsite; the latter of comparatively unaltered sandstones. The strata have been fully described by Dr. Honeyman,* and the fossils enumerated as follows:

Fossils. "Similar (*i.e.* A.) rocks.. in the Marshy Hope part of the Antigonish and New Glasgow road, at the Antigonish and Pictou county-line.... contain *Petraia*, *Lingula*, *Cornulites* and a *Cyrtoceras*, ... and at the west end of the Marshy Hope... abundance of *Athyris* in casts."

Lochaber fossils. On the west side near the head of Lochaber† in John McNaughton's Brook, Dr. Honeyman obtained *Petraia* and other fossils. A small collection, including *Bellerophon*, *Athyris*, *Chonetes* ?, *Leptocœlia*, *Strophomena subplana* ?, *S. rhomboidalis*, encrinites and other forms, was made here in 1885; another by Mr. Weston and Mr. Robert in 1886. The rocks consist of dirty-gray and greenish, micaceous, white-weathering slates, blotched with quartz; and further west, of greenish, quartz-veined, sparkling quartzite and slate, overlain toward the south and north by red Devonian slate, and underlain by the traps of the hill. More evenly bedded slates are found in other brooks, as for example in McGillivray Brook, a branch of West River; but the whole band is small, although including, according to Dr. Honeyman, at the north-east end, the characteristic fossils of C. A small patch crosses Lochaber to the eastern shore north of the chapel.

Contact with Devonian and Pre-Cambrian.

Avondale and Sutherland's River basin. A larger basin extends from Avondale‡ up Barney's River to Kenzieville, then to the east branch of French River and to Sutherland's River, containing important areas of both the lower and upper groups. Its boundaries are both defined: at Avondale and Glenshee

* Trans. N. S. Ins. Nat. Sc., Vol. IV., p. 443, and Vol. V., pp. 194 to 199.
† Trans. N. S. Inst. Nat. Sc., Vol. IV., pp. 76 and 440; Canadian Naturalist, Vol. V., p. 294.
‡ Trans. N. S. Inst. Nat. Sc., Vol. III., p. 9; Vol. IV., p. 193.

it plunges beneath Carboniferous strata, but in most parts of its course is in contact with Cambro-Silurian rocks. All the Silurian areas are singularly free from volcanic intrusions as compared with the Cambro-Silurian, but the rocky ridge south-east of Kenzieville is intersected by dykes of dark fine crystalline diorite. Other features of interest in connection with this basin will be again referred to. Few volcanic rocks.

On Moose River, near the post-office of that name, a Silurian trough, possibly of this age, lies among the older schists. Another belt runs down the East River of Pictou, generally on the north side from near its head to Springville.* On the upper part of the river the basal sandstone and overlying black slates alone are present, while toward Springville, higher rocks prevail, characteristic fossils abounding in all. On the brooks near Beaver Lake, Kerrowgare and Sunnybrae, Medina and Clinton fossiliferous strata are in contact with Cambro-Silurian and perhaps older rocks, and are overlain to the southward by a wide belt of Devonian gray slates. In the black slate, near Kerrowgare, search was made for coal, several pits being sunk to a depth of about twenty feet, and $400 wasted in the search. Moose River basin. East River of Pictou basin. Search for coal.

In Blanchard Brook, not far above the bridge at Sunnybrae, Silurian sandstone, rich in fossils, is underlain by porphyritic and other Cambro-Silurian rocks, followed again upstream by Medina sandstone.

On the shore of the little lake, south of Sutherland Lake, whitish, greenish and bluish-gray micaceous, compact quartzite and argillite are cut by dykes of dark-gray calcareous trap. Rocks of similar character are found in the brook from this lake, as far as the road, where they contain fossils, much of the land being barren. Sutherland Lake basin.

E 2. Lower Clinton.

These rocks, as they occur at Arisaig, have been described by Dr. Honeyman in the papers already referred to. At the mouth of Arisaig Brook they are dark, rusty-weathering, papery slates, containing hard concretionary bands full of fossils. They extend to the old mill below the shore road, where many fossils were collected by Mr. Weston, among them two species of graptolites. They must be of considerable thickness, but are too much crumpled to be accurately determined. Unlike the rocks to the westward, which are not greatly disturbed, those east of Arisaig Brook are nearly vertical, sometimes overturned. In the brook east of the old road and west of Arisaig chapel are dirty-greenish and bluish-gray slates, probably the upper part of this group, succeeded in one of the branches by higher rocks, Arisaig Brook. Graptolites.

* Acadian Geology, p. 568; Supplement, p. 76: Trans. N. S. Inst. Nat. Sc., Vol. III., p. 8, and Vol. V., p. 209.

Iron ore. includin a band of red hæmatite, two feet thick at the western side of the brook, but thinning out to one foot on the east side, the outcrop being only four feet long. The hæmatite is cut by a quartz-vein, which also cuts the enclosing green slates. The ore, by the way in which it replaces the slates across the layers, partaking of their bedding, seems to be a more or less concretionary contemporaneous mass like the limestones at the mouth of Arisaig Brook. Covered by twelve feet of coarse stratified gravel, below the road, in the brook, are good outcrops of dark slates, which continue to the shore, and are underlain by Medina sandstone, which in turn gives place to the Frenchman's Barn series. The shore road is on a belt of black slate the whole distance from Arisaig to Doctor's Brook, newer strata being everywhere to the southward. In the small brook at the carriage factory, below the road, they are underlain by Medina sandstone, greenish-gray, wrinkled, rippled, coherent, micaceous, flaggy and thick-bedded, containing lingula, encrinites and other fossils, underlain by the felsitic rocks; and the same succession is found in Doctor's Brook.

Medina and Pre-Cambrian? underlying the Clinton black slate.

Bailey's Brook. On the east branch of Bailey's Brook are soft, gray, crumbly argillaceous shales and black slates, cut by quartz-veins which carry a small quantity of iron pyrites, and have been mined. They contain hard bands, have a variable dip and show no fossils, although in blocks, apparently derived from them, were found brachiopods like those in the hard concretions at the mouth of Arisaig Brook. The relation of these to the Cambro-Silurian strata of the neighborhood will be understood by reference to the map.

Mine?

Barney's River. The contour of the hills and valleys of Barney's River depends on the distribution of the Silurian and Cambro-Silurian rocks; and the troughs of the former can be plainly defined from the tops of the hills. They seem to have been deposited in depressions among the Cambro-Silurian hills, just as the Carboniferous limestone and conglomerate among those composed of Pre-Carboniferous rocks. Where Silurian strata come from beneath the Millstone Grit in Barney's River, below John McPhee's house, they consist of greenish flinty sandstone, from the thread-like meshes or joints of which water oozes depositing a small quantity of salt. Upstream these are overlain in cliffs by soft gray and greenish rusty-weathering argillite, containing obscure fucoids. Higher still are Clinton shales—dark, bluish-gray, papery, micaceous, somewhat sandy, rippled, and broken into pieces by cross-joints.

Salt spring.

Dykes. A dyke of dark fine diorite or hornblende-rock cuts these slates: its effect in some parts is not discernible; in others, the slates are rendered somewhat more porcellanous and coherent near the contact, although a few feet away the proximity of the dyke would not be suspected.

In the west branch of Barney's River, from the mouth of William Murray's Brook, soft, greenish argillaceous shale, probably Upper Clinton, paves the brook for some distance downstream, and is cut by a dyke of flinty, trappean rock, sixty feet wide or more, of the most stair-like aspect, the jointed blocks being so arranged that one might by their means scale the face of the cliff. It overlies, or has overflowed, the shales, which are considerably altered at the contact and filled with blotches of calcspar, although the bedding is not much disturbed, the layers being cut clean off where they rise against the dyke. West branch of Barney's River. Dyke.

The scenery of the gorge is picturesque, the birches and spruces rooted in the mural, furrowed cliffs, contrasting agreeably with the rough masonry of the trap and the long lines of bedding of the shales. Lower down, arenaceous layers, two inches thick, accompany the shales.

In the middle branch above the fork of the east branch, nearly continuous exposures of gray slate occur, cut in one place by a dyke of dark-gray diorite and full of small veins of mixed calcspar and quartz. Higher still, another dyke is in contact with greenish argillite, just below the telegraph road. Above the road, bluish-gray, soft, papery argillite, breaking into long needle-shaped pieces, is underlain by flinty, coherent Medina sandstone. On the east branch of French River, above the Piedmont road, the fine outcrops of these rocks succeeding the Medina, contain the very beautiful lingula-nodules described by Dr. Honeyman. Middle branch of Barney's River. Dykes and veins. Lingula nodules in French River.

Below the Carboniferous rocks of the west branch of French River, are others which form the extension of the Cambro-Silurian ridge of the Piedmont hills, comprising reddish, compact or fine-grained syenite or quartz-felsite; diorite, conglomerate and quartzite, followed by gray, soft, Silurian shales which extend a great distance above the road, and are overlain by gray and reddish, micaceous, flinty sandstone, containing a small spiral shell, brachiopods, encrinites and other fossils. Above Archibald McPhee's are gray, greenish and bluish-gray shales, with sandy, micaceous, flaggy layers, often greatly contorted, interstratified with bands, one foot thick and less, of greenish or bluish-gray micaceous, shelly, flinty sandstone, with half-inch quartz-veins mixed with ankerite. Higher up, the shales are crumpled, papery and crumbly, soft and micaceous, and the bands of flinty sandstone or quartzite sometimes five feet thick. W. branch of French River. Fossils.

E 2. Upper Clinton.*

These rocks as they occur on the Arisaig shore and in French and Barney's Rivers, have been already described. They are well seen

* Trans. N. S. Inst. Nat. Sc., Vol. III., p. 13, and Vol. IV., p. 52, line 4.

Arisaig and Doctor's Brooks

above and below the bridge on Arisaig Brook, where they consist of gray and greenish slates and flags, overlain by the strata containing the bed of iron ore; also above the shore road, in the brook at the carriage factory, and in the east branch of Doctor's Brook. In Doctor's Brook, above the shore road, are greenish-gray, quartz-veined, pearly, soapy slates, interrupted by a knob of greenish flinty felsite, containing quartz; beyond, the slates, which contain thin layers of gray limestone, bear a striking resemblance to those near Dewar's mills in Barney's River (p. 45 P, line 2,) and are thickly set with fucoids, encrinites and brachiopods. Upstream they become more flaggy and are succeeded by dirty-greenish, calcareous, higher rocks.

Smith Brook.

Faults.

On the shore, Mr. Weston collected graptolites of at least two species from a bed about 480 paces east of the mouth of Smith Brook (p. 39 P, line 6). The faults in the green rocks east of this brook, mentioned in the section, are perhaps only thrusts or folds without great displacement. The last, fifty paces west of the graptolite beds, seems to be only a crumpling of a mass of these strata about fifteen yards wide, accompanied by a thrust of the eastern rocks a few feet over the crumpled portion, and perhaps a corresponding displacement between the latter and the western undisturbed rocks. On account of the undulations between this point and the mouth of Arisaig Brook, no good section can be obtained. The thickness is, consequently, uncertain, but might, perhaps, be ascertained from other sections. The contact with the overlying E 3 group is by a fault, the edges of these strata running into those of E 2 on the reefs; but the amount of throw has not been determined. Other faults, including the great dislocation which separates all these rocks from the Cambro-Silurian along the Hollow, may be studied on the map. The E 2 group ends at the little cove 100 paces west of Arisaig Brook, but the boundary between the upper and lower groups of E 2 is not very clear. They do not resemble E 3, nor can these latter be confounded with E 1, the most siliceous of the Arisaig series.

Fault along the Hollow.

French River.

Among the nearly continuous outcrops of the east branch of French River, rocks, probably Upper Clinton, hold graptolites.

Moose River.

The greenish slates of Moose River, already described (p. 43 P, line 7), are, perhaps, of the same formation. They hold fossils in abundance, and are well seen in the river for a short distance below the bridge, forming a small outlier among older strata.

East River of Pictou.

John McDonald's Brook,* about two miles below Sunnybrae, on the south side of the East River of Pictou, flows among cliffs and reefs of rock, apparently in part of this age. At the bridge on the post-road are soft, soapy, evenly-bedded, dark bluish-gray and gray argillaceous

*Trans, N. S. Inst. Nat, Sc., Vol. III., p. 65.

shales, jointed and veined with threads of quartz, and containing a few entomostracans. Further south, argillites are associated with greenish and brown sandy shales and sandstones, with thin layers of light-gray limestone, very like the rocks of the west branch of French River above Glenshee. Above them, in the brook, are massive Devonian (?) quartzites full of specular iron, perhaps owing their alteration to a mass of rusty-weathering whitish granular rock seen in a cliff on the left, and traceable for some distance from the brook. Immediately above this, at the next bend of the brook, at the mouth of a brooklet from the westward, are similar rocks, together with a banded, porcellanous, black and gray argillite. Above this tributary, there extends as far as an old dam, greenish pearly slate, to which other Devonian rocks succeed. These strata, which require further examination, may be wholly of Devonian age.

Devonian rocks

E 3. Niagara. *

Cape George.

About four hundred and fifty yards west of Indian Brook, on the shore near Cape George, light-gray and reddish evenly-bedded quartzites, covered on the surface with worm-burrows (?) and overlain by a concretionary nodular, very calcareous bed, sometimes bright-green, with layers of bright-red argillaceous shale, perhaps the equivalent of the "red stratum" of Arisaig (p. 37 P, line 42), and cut by diorite and syenite, underlie Carboniferous conglomerate. The quartzites are studded with small black spots or phosphatic nodules, obscure encrinites, *Cornulites serpularius*, a *Chonetes*, and other fossils.† Further west, another patch consists of light bluish-gray broken quartzite or sandstone, with a few black nodules; greenish quartzite and soft bluish-gray crumbling argillite, with small, hard gray limestone concretions and thin layers; dark-purple, red and green crumbling argillite and sandstone, full of calcareous nodules. These rocks are very rich in fossils—*Spirifer*, *Rhynchonella*, *Lingula*, two species of *Beyrichia*, upper and lower valves of *Discina*, and other forms.†

Phosphatic nodules.

Fossils.

McAdam's Brook.

In McAdam's Brook, at Arisaig, the red stratum between this and the next group above crosses below the road, near the fork of the two branches, and can be traced from this point westward to the shore. It is also found in Arisaig Brook, in that west of Arisaig chapel, and on the old road east of the Trunk road. Above the road, in Smith Brook, gray, massive, flaggy and shaly sandstone and slate are succeeded at a ten-feet fall by massive, maroon-colored argillite, which would seem to be a depauperated form of the iron ore band;

Smith Brook.

* Trans. N. S. Inst. Nat. Sc., Vol. III., p. 7.

† Determined by Dr. Honeyman.

Contact with Devonian.

above which is a considerable thickness of shales, lying in a synclinal, and covered by red Devonian slates.

Iron ore of Arisaig Brook.

The iron ore of Arisaig Brook, from which Mr. Weston made a large collection of fossils in 1886, and of the brook to the eastward, apparently belongs to this group. Where cut, on the Trunk road, it varies in thickness from one foot three inches to two feet six inches, is shaly and oolitic, full of fossils, like the Blanchard ores, veined with quartz and calcspar, the containing rocks being thrown into small sharp folds.

Doctor's and McNeil's Brooks.

In Doctor's Brook, this group is well developed. Near the mouth of McNeil's Brook* is a small outcrop, apparently of this age, of greenish and reddish soft argillite, not well seen. To the eastward, as far as Malignant Cove, few rocks are met with.

E 6. Lower Helderberg.

Mr. Billings' description of fossils.

The Arisaig fossils described by Mr. Billings (Palæozoic Fossils, Vol. II., Part I.), were all collected by Mr. Weston from the upper part of this formation, west of Stonehouse Brook, where fish remains were also obtained by him. Its base is seen at the red stratum in Joseph McDonald's Cove. Some of the entomostraca collected from this neighborhood have been described by Prof. T. Rupert Jones.†

Sutherland's River.

A large development of Lower Helderberg and underlying Silurian strata occurs in Sutherland's River, above the St. Mary's road.‡ Immediately above the bridge are high cliffs of gray, fine, smooth, somewhat slaty, crumbling argillaceous shale, with more coherent layers of micaceous sandstone; succeeded higher up by shelly shales and flags, associated upstream with greenish, flinty, quartz-veined fine sandstone or quartzite, crowded with fossils; and with greenish, more coherent, and siliceous rocks, containing large spheroidal concretions abounding with shells.

Volcanic rocks.

In a cliff, about a mile above the road, a greenish, massive calc-veined trap and porphyritic, finely crystalline felsite, containing little hornblende, are seen to cap the argillites. Above the trap are light greenish-gray fine micaceous flinty sandstones, or quartzites, with threads of quartz and much calcspar in the joints. Flinty fine sandstone and argillite form a beautiful gorge, with falls and cascades fifteen or twenty feet high, the river coming down in two rocky parallel runs, nearly on the strike, with an island twelve feet high between. In this gorge are large concretionary masses or rolls, full of fossils. Higher still are outcrops of greenish, flinty, fossiliferous sandstone, with patches of coarser grit and layers of gray, fine, coherent micaceous

* Trans. N. S. Inst., Nat. Sc., Vol. IV., p. 51.

† Transactions N. S. Inst. Nat. Sc., Vol. V., p. 313, and Quarterly Jour. Geol. Soc., Vol. XXVI., p. 492.

‡ Trans N. S. Inst. Nat. Sc., Vol. III., p. 71, and Vol. IV., p. 463.

argillite, with quartz-veins sometimes one foot in thickness. These are succeeded by Cambro-Silurian, and perhaps older strata. The rocks of this formation at Blanchard and Springville* have been examined by Sir J. W. Dawson and Dr. Honeyman, but many details of their distribution have yet to be ascertained. Quartz veins.

F. Devonian.

As already stated,† a broad belt of rocks, similar to those regarded in New Brunswick and Newfoundland as Devonian,‡ extends from the Strait of Canso to Lochaber, thence keeping south of the East River of St. Mary's and of the East River of Pictou to strike the Intercolonial railway near Glengarry, form the high land south of Truro, and pass unconformably beneath the Carboniferous of Stewiacke River. A second belt of the highest members of this series extends from the Arisaig Trunk road westward to Bailey's Brook. Similarity to Devonian of New Brunswick and Newfoundland.

The strata of the first belt are separable into three distinct groups, corresponding closely with those of New Brunswick, as follows:— Classification.

Lower Conglomerate Group	= Bloomsbury Conglomerate
Middle Gray Sandstone and Slate Group	= Dadoxylon Sandstone and Cordaite Shale
Upper Red Slate and Sandstone Group	= Mispeck Group.

A zone of the lowest group, five or six miles wide, runs due west from Guysborough Harbour to South River Lake, keeping south of Roman Valley. The second and by far the most largely developed group occupies most of the country north of Guysborough Harbour and Roman Valley, to the Strait of Canso, Upper Tracadie and Merland, and extends in a narrow belt on both sides of the lower group as far as Lochaber, where it is only half a mile wide, increasing, however, to four miles at Kerrogware, and still more to the westward. The upper group, nowhere exceeding six miles in width, runs from Merland to the westward of Lochaber. At the base of this or the top of the preceding group, or possibly forming an independent sub-division, is a belt of greenish and red slates and rusty-weathering, flinty, gray sandstone containing iron ore, which has been worked at several places. The upper rocks are found again near Union railway station, and also at McAra's Brook. Distribution. Possibility of a fourth group. Iron ore.

When the Devonian rocks on the Strait of Canso and Cape Breton were examined in 1878, § they had not been subdivided. It may be Devonian of Cape Breton.

* Trans. N. S. Inst. Nat. Sc., Vol. III., p. 65.

† Page 6 P; Geol. Survey Report for 1885, p. 62 A and 50 E.

‡ Geol. Survey Report for 1870–71, p. 170. Acadian Geology, p. 502, and Supplement, p. 69; Murray's Geological Survey of Newfoundland, p. 48.

§ Geol. Survey Report for 1877–78, p. 16 F., and Report for 1879–80, p. 32 F.

well, therefore, to supplement the description of them by a few remarks; although further investigation is necessary to indicate clearly the areas occupied by the different groups.

Carboniferous limestone. The limestone of St. Peter's, Campbell Hill and Tom's Brook* is Carboniferous, as shown on the sheets 17, 20 and 21 of the map. The rocks of the district are for the most part Middle and Lower Devonian, except the red argillite (p. 19 P) in some of the L'Ardoise brooks and elsewhere, as on McNab Lake, Tom's Brook, the west branch of McNab Brook, the St. Peter's road not far north of McNab Cove (p. 22 P) and west of Salmon Creek chapel, Detter Brook,† and the north side of Madame Island (pp. 35 and 38 P). On the mainland, those in the neighborhood of Melford Creek (p. 41 P), Eddy Cove and Middletown are probably Upper Devonian.

Mistake in Report for 1879-80. When the Geological Survey Report for 1879-80 was written, only the rocks of the shore at Harbour Bouché had been examined; and in the section on p. 44 F. three distinct groups are included. Nos. 1, 2 and 3 of the section belong to the Carboniferous conglomerate. G 1 m.; No. 5, appears to be the only Devonian rock; while No. 4 is, as there doubtfully suggested, the limestone of Plaster Cove and Pirate Harbour, unconformably overlying the other groups. This **Mistakes on Sheet 22.** was partly corrected on sheet 22 of the Report for 1882-83-84; but it was not then known that the limestone of Blue Cape (p. 61 F.), instead of passing south of Harbour Bouché to join the outcrop on the shore at North Canso, runs out to the shore between Cape Pond and Cape Jack; that consequently, the measures between Cape Pond and North Canso, although Carboniferous, belong to the basal **North Canso.** group; and that the limestone of the section at North Canso probably overlies these Horton shales unconformably at their junction with the Devonian. The Devonian rocks are also shown too near the railway between Little Tracadie River and the winter road east of the 68th mile post. The relation of the different groups on the Cape Breton side of the strait is still somewhat obscure, owing to the number of unconformities. On sheet 22, a small patch of calcareous Horton shales has been omitted‡ immediately east of the Pre-Cambrian boss there shown. It is near a band of black slate like that seen half a mile north of McDonald Brook on the Nova Scotian side and also in the road near the mouth of Horton Brook, which is probably distinct from the calcareous shales, and appears again on the railway near Cape Porcupine, west of Port Mulgrave behind the limestone quarry (p. 61 F.), at the mouth of Pirate Harbour, and thence

* Geol. Survey Report for 1877-78, pp. 18 and 21 F.
† Geol. Survey Report for 1879-80, p. 34 F.
‡ Acadian Geology, p. 391.

for some miles close along the shore. It is perhaps also the black band of Oyster Pond Brook (p. 50 F), and of Arichat Harbour and Head (p. 37 F). As already pointed out, some or all the rocks of Horton's, Brown's, Lamey's, Queensville and McMaster's Brooks (p. 51 F), may belong to the Horton Group; but their unconformity to the overlying limestone is evident. Unconformity of the Carboniferous limestone and conglomerate.

In the millbrook at Mulgrave, between the mill and the shore, the exposures consist of greenish and gray, flinty, flaggy sandstone and conglomerate, largely composed of red syenite debris, and probably representing the rocks round Cape Porcupine. The rocks of Hartley's Brook are much more altered. On Pirate Island, red argillite and Arichat conglomerate, veined with quartz, are underlain by the black slate, which follows the shore nearly to Steep Creek, where a patch of Carboniferous limestone comes in. From the bridge eastward, quartz-veined conglomerate and fine, reddish-gray sandstone and argillite resemble the rocks of Auld Cove, and should perhaps not be separated from the Horton Group, but may represent transition beds between the Carboniferous and Devonian. Port Mulgrave. Pirate Cove. Outlier at Steep Creek.

On the shore, near the end of the Middletown road, reddish fine sandstone and shale, jointed and flinty, accompany dirty-green or gray coherent and slaty argillite. Following this road, outcrops of coarse conglomerate, grit and red and purple argillite, perhaps Upper Devonian, are met with; and further out, green argillite, showing a small *Lepidodendron* and purplish, greenish and gray slates, often pearly and mottled, like those (p. 49 P, line 11) at or below the base of the upper group. In the railway cuttings immediately east of Cape Porcupine station, are banks of dirty greenish-gray flinty slate or fine sandstone. At the 74th mile post, greenish flinty conglomerate is succeeded in a cutting by dark slates and greenish or dark flinty sandstone. Similar alternations follow the railway to the shore, conglomerate being particularly abundant east of Auld Lake. In the little brook crossing the road half a mile east of North Canso school, flinty, gray and greenish-gray quartz-veined quartzite has a vertical strike along the stream. Lower down the dip is 120° $<$ 45°. This probably points to a downthrow on the east side, which may extend to Mathy Settlement. Middletown. Cape Porcupine. North Canso. Fault.

Lower Conglomerate.

Lower Devonian strata run from Guysborough Harbour to South River Lake, and are also found about Cape Porcupine, but the whole group requires further study, the line of demarkation between it and the red and green slates being less satisfactorily defined than the boundary between the two latter; and the large development of con- Obscurity in the boundary.

glomerate being in part, perhaps, connected with the volcanic masses which occupy the district in which it occurs.

Tracts not previously subdivided. On the eastern side of Guysborough Harbour, at Ragged Head,* Madame Island and elsewhere, there are also large tracts of conglomerate.

Guysborough Harbour. On the west side of the harbour, below the Boylston drawbridge, is a reddish coarse conglomerate, like that of Ragged Head, blocks of which are seen also in the Carding-mill Brook for a great distance up stream, and also in the fields towards the shore. Trap. Many blocks of trap occur west of Cutler Cove, but no outcrops.

Along the road to Guysborough Intervale, on the south side of the harbour, above the bridge, whitish-gray flinty sandstone, grit, slate and conglomerate form a high, rocky hill. Iron ore. Hæmatite is universally found in films and spots, and sometimes in large quantity in the brooks and on the hills. Cuddihy Lake. Gray sandstone, disturbed by dykes of diorite, succeeds to greenish and purple slates on the road to Cuddihy Lake.

Reddish and light-gray quartzite, very coarse, coherent sandstone and conglomerate are displayed on the back roads and fields in this vicinity, also associated with trap; along the shore, and on the shore road from Guysborough to Salmon River, Chedabucto Bay. no other rocks are in place, except on the south side of Ingersoll Creek, where they are in contact with Carboniferous, as on the opposite side of the harbour.† Following the roads up Salmon River, Salmon River. this formation is exposed, with a doubtful easterly dip, the river being the boundary between the gold-bearing series and the Devonian for a great distance; for, if in places the latter occurs on the east side of the river, it can only be on the flats.

At the second bridge the water is deep, but not tidal; the strata on the right bank are doubtful flinty quartzose rocks of the whin and granite series, which also cross to the left bank about 300 yards above the bridge. In the brook that flows into the river, immediately above the bridge on the Tor Bay road, Graphitic slates mined. are several pits, in which search was made for coal or plumbago in a black broken slate. Higher up, the brook comes across jointed conglomerate and sandstone, with layers of soft green shale, full of matted plants. Higher still, and apparently underlying, are dark, micaceous, graphitic or coaly, sandy shales, also full of plants; Fossil plants. greenish and gray flinty slates and quartzites, holding *Psilophyton*, cut by calcspar veins, with much hæmatite and a wonderful abundance of silvery mica. Some of the finer beds are very like the green slates of the base of the higher group, but coarse beds greatly predominate. The pebbles of the conglomerate are of whin, often gneissic, but none of granite were seen.

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* Geol. Survey Report for 1879-80, pp. 36 P and 48 P.

† Geol. Survey Report for 1879-80, p. 46 P; Acadian Geology, p. 350.

About half a mile higher, flinty whin of a very light color is in the river, while on a track to the road, conglomerate is evidently the country rock. Conglomerate is well exposed on the Salmon River road, but still better on the old road and its branches. Between the two roads at Roachvale, blocks of conglomerate abound, while above the old road in the School Brook, bluish and greenish-gray slate and quartzite, massive or shaly, dip upstream at a moderate angle. Higher still, light-gray flinty slate and quartzite again dip upstream, and still higher are penetrated by a small dyke of gray amygdaloid, associated with conglomerate, a large barren vein of quartz being near the contact. Roachvale.

In McAllister's Brook no rocks are laid bare up to the old road, but above this road greenish and blackish brecciated strata, full of threads of quartz, and like those of page 52 P, line 32, contain specks of copper pyrites, and have been worked for copper. With them is associated a soft grit, and immediately above, trap, syenite and porphyry. Soft light-gray shales are again visible at the top of the cascades, somewhat pearly, and like those in which copper was found at Erinville. Slates of the same character occur in Cuilnamuc Brook, and in all cases, perhaps, belong to the middle group. Higher up this brook, however, is an interesting display of dark, rusty, compact quartzite, conglomerate and slate, containing small pyritous quartz-veins, succeeded by diorite and trap. On the Cuilnamuc road, near Ogden, blocks of bluish-gray slate, sandstone and conglomerate accompany others of diorite and felsite, dykes of which alter the former on North Branch Lake. Tom McDonald's hauling-road, near Reid's, displays columnar amygdaloid, intersecting red sandstone and other greatly altered rocks, veined and blotched with quartz; and again on the lake southwest of Grant Lake, gray, greenish and reddish slates are cut by trap. Near the outlet of Grant Lake, mottled slates of similar colors, serpentinous, altered, and sometimes very coherent, are mixed with conglomerate, and on the wood road from this lake to the shore road, red argillite, purplish grit, sandstone, conglomerate and trap accompany whitish, flinty sandstone or quartzite. Similar exposures occur about Ross and Campbell Lakes, conglomerate and quartzose sandstone being also in the brook from Ross Lakes, both below the fork and in the branch from the westward. From the road at Farrell's, southward to the Glencoe shingle-mill, blocks of conglomerate appear for a short distance, while near the mill the rocks consist of bluish-gray pyritous slate, flinty sandstone and conglomerate. From this point to Kinney's, gray slates occur. On the lakes in the neighborhood, however, conglomerate and red flinty slates, containing much specular iron and cut by dykes, extend to Croak's Lake, and a great part of the way to Farrell's.

McAllister's Brook. Copper "mine." Cuilnamuc Brook. Volcanic rocks. Grant Lake. Ross and Campbell Lakes. Iron ore.

Glencoe. At Glencoe, the gray flinty quartzite and slate, which occupy the road from Erinville, are succeeded, from Shea's Brook northward to the school, by bluish-gray slates; these, near the school, by green and red soft slates, perhaps of the upper group, the structure being somewhat obscure. Near Shea's Lake are outcrops of flinty flags, Arichat quartzite or sandstone; on the lake shore, reddish-gray fine sandstone and smooth red argillites have seams full of blotches of white calcspar. **Roman Valley.** This lower Devonian formation consists of flinty gray quartzite, grit and conglomerate on the shore of Cuddihy Lake; and in the adjoining tributaries of Roman Valley, of greenish-gray slate and sandstone, obscurely interstratified with porcellanous slates.

Giant Lake. On the road from Erinville to Giant Lake, purple argillite, bluish-gray flinty sandstone and conglomerate are occasionally seen, cut on the road to Hoppenderry by dykes of diorite, and well exposed nearer South River. The dark and bluish-gray splintery slates of Porter River and the small tributary south of Angus McIsaac's belong probably to **South River of Antigonish.** the middle group, as well as those about the head of South River and the dark slates in the north-west branch of Salmon River above the copper mine. These latter are associated, higher up, with trap and diorite, to which succeed sandstone or quartzite, containing hæmatite and pyrites, and, about the lakes, conglomerate and shale.

Following the roads from Roman Valley to Upper South River, we meet with rocks of this formation in contact with higher Devonian strata. On the shore of Flat Lake, and as far down McPhee's mill-brook as McGillivray's mill, flinty sandstone, grit and conglomerate are *in situ*, cut here and there by dark-gray amygdaloid, and covered with green soapy slates.

South River Lake. No conglomerate was seen at the head of South River Lake on the west side; but on the east, ledges of conglomerate, like that of Giant Lake and Arichat, seem to run parallel to the lake, but without any well defined dip. Further from the lake, near the outlet of a small **McNaughton Brook.** lake on McNaughton Brook, are cliffs of very coarse conglomerate, with patches of flinty sandstone or quartzite, cut in places by trap dykes and containing pebbles of white grit or sandstone, like the Guysborough quartzites. It is associated with a grit so much altered as to pass for a granular quartz-felsite.

Following down the brook, similar exposures are seen; and between **Trap.** it and the main brook the grits and sandstones are in contact with a knob of fine trap, which also crosses the brook, in which it is succeeded downstream by bluish and greenish-gray flags, apparently belonging to the upper group and overlying the conglomerate, but divided from it by a mass of trachytic rock, a spur of which cuts the slates lower down. **Fossil plants.** From these flags many plants were collected by Messrs. Weston,

Robert and myself, including "fragments of stipes of ferns, also a *Sigillaria*, with narrow ribs, but not determinable," thought by Sir J. W. Dawson to belong probably to the lower part of the coal formation or Millstone Grit. They are followed downstream by flinty sandstone and shale, causing cascades in a gorge. Crossing northward from the mouth of the gorge at the head of the intervale, the overlying rocks, consisting of flinty quartzites, cut by trap, are succeeded by green slates like those at the base of the upper group, (p. 49 P) overlain as usual by reddish, purple and bluish-gray slates and flinty quartzose sandstones, stained with specular iron, often in connection with the quartz-veins which in great numbers cut these rocks. In the upper part of McNaughton Brook, and also in McMillan Brook, slates and conglomerates are broken by masses of trap. Lower down in the latter brook the conglomerate again gives place to gray and dark slates and quartzites, containing specular iron and ankerite; and the same sequence will be observed on the west side of Lochaber, along Roman Valley and other contacts still to be described.

Higher strata. **Trap.** **Iron ores.**

Middle Gray Sandstone and Slate Group.

Reasons for separating a fourth group.

To the upper part of this group, or the lower part of the next, belong probably the green and rusty slates just described in McNaughton Brook. As they here underlie the red slates, all the gray beds being wanting; but sometimes, as in the McAra's Brook belt, are not found with them; and as they are also absent from the great band of gray sandstone and slate along the East River of Pictou, they perhaps constitute a distinct group. This can no doubt be determined further west, and in the meantime they will be included here.

Fossil plants.

Although plant-remains are not absent from the lower and upper groups, they are nowhere so abundant as in the intermediate group which includes the beds of Tracadie and Riversdale, from which plants were collected by Messrs. Weston and Robert. The greenish argillite and flinty sandstone, gray, quartz-veined, white-weathering sandstone and grit, above the railway bridge in Little Tracadie River, perhaps belong to this group, and are also found at Grosvenor,* at the head of the Mathy Settlement and at the outlets of Summers Lake.

Grosvenor.

Tracadie River.

Below the still waters in the north branch of Tracadie River, and in other neighboring brooks, bluish-gray and greenish, somewhat nacreous slates alternate with bands of quartzite; and on the road from Upper Big Tracadie to Boylston, with conglomerate and quartzite. In the colored settlement at Silvey Brook, and also at the head of Brymer Brook, the slates are bright sea-green. In Tracadie River, above

* Geol. Survey Report for 1879-80, p. 43 F.

Upper Big Tracadie post-office, light-bluish and greenish-gray pearly slates or shales are interstratified with bands of the most coherent quartzite and greenish-gray nut-conglomerate. Blocks of diorite were also found, but not in place. In Silvey and Hurlbert Brooks these rocks are full of quartz-veins, and the slates of the barrens between Five Mile Lake and the Mathy Settlement, and in Meagher Brook, contain veins more than one foot thick. Above McGillivray's mill, bluish-gray slate and quartz-veined quartzite undulate in gorges with cascades and pools, being sometimes curiously rippled. In the cliffs of a brook from the westward, below the above mentioned post-office, light bluish-gray micaceous slate is associated with shaly, fine, flinty sandstone, full of small veins of quartz containing ankerite, which weathers rusty. In a dark shiny slate with a few such veins, search was made for gold in a shaft twenty feet deep.

Quartz veins.

Gold sought.

North side of Guysborough Harbour.

Quartz veins.

Limestone.

On the north side of Guysborough Harbour, near Brymer Brook (Sheet 24 of Geological Survey Report for 1882-83-84), the hills show outcrops of slate, with veins of milky quartz, which in the brook are associated with felsite and trap, bluish-gray shaly limestone, coarse gray quartzite and grit.

Quartz veins.

In Paul Leet's Brook, not far above tidewater, a vein of quartz, one foot thick and less, runs in the bedding of sea-green argillites. At the falls and cascades higher up, greenish and dark-gray slate and sandstone veined with white quartz, contain blotches of ankerite or ferruginous calcspar, sometimes six inches thick. Some of the veins show masses of quartz six feet wide, but not continuous, displacing the beds. The rocks are in part so mixed as to form a breccia, and are associated higher up with greenish conglomerate.

Merland.

In Brandy Brook a considerable display of quartz-veined quartzites and slates is seen, and also on the upper reaches of Tracadie, Guysborough and Afton Rivers and the Monastery Brook about Merland and South Merland. Above Merland school, flinty sandstones contain argillaceous, softer, ferruginous nodules about the size of a hen's egg.

Guysborough River.

Mira Falls.

Drift coal.

Slate quarry.

In the branch of Guysborough River flowing from Gavin's Lake, are bluish and reddish-gray, flinty quartz-veined quartzites. From the confluence with a branch from another lake, greenish-gray slates, cut in the bedding and across it by quartz-veins, continue as far as the road at the head of this lake and to the post-office at South Merland. In the main stream above Mira Falls, strata resembling those of the Monastery Brook are seen. High cliffs overhang the falls and the gorge below, in which dark gray slates, associated with flinty sandstone and quartzite, have been quarried. The pieces of coal said to be found in the river are, probably, derived from the drift, which is largely composed of soft Carboniferous debris. Slates which have been

quarried occur in all the neighboring brooks. At and above Mira Falls, they dip nearly vertically downstream. The concealed spaces are too great to admit of a section being made; but the thickness of strata exposed, after making due allowance for repetition by folding, is evidently very great.

In Guysborough River, the reddish and gray jointed sandstone and porcellanous slate seen above the Mink Brook, perhaps belong to the lower group. Atwater Brook displays light-gray, flinty quartzose conglomerate, grit and slate, streaked with green and rusty pyritous bands. In Butler's Brook are ledges of grayish quartz-veined sandstone and slate, and near Fitzgerald Lake the quartz-veins are spotted with ankerite, and have been mined. **Mink and Atwater Brooks** **Quartz veins mined.**

Grayish slates and quartzites are also exposed at falls and cascades, cliffs and rapids above Durney's sawmill, on the Monastery Brook. From these rocks below the mill, a collection of fossils, made by Mr. Weston, and examined by Sir J. W. Dawson, yielded "*Lepidodendron corrugatum*, *Stigmaria* rootlets, and remains of ferns, perhaps *Cyclopteris Acadica*," forms supposed to be characteristic of the Lower Carboniferous (Horton Series). **Monastery Brook.** **Fossil plants.**

Gray slates are in the Merland road, from the Monastery road eastward; while the red rocks to westward of the fork are probably higher. Grayish slates and quartzites, including the bright-green slates of Silvey Brook, occupy the Afton road for some distance. In Afton River, immediately below Boyle's at Upper Afton, the slates of Durney's mill are found exposed, and overlain toward Flynn Lake and New France by the upper red rocks and by Carboniferous strata. At the cross-roads at Healy Lake and at Delahanty's, green and gray pearly slates, with red bands, indicate the upper part of this group. **Afton River.**

Following down Afton River, from the outcrops mentioned above, gray slates and sandstones at the road contain minute elongated, carbonized markings of plants, probably rootlets. Lower down, jointed, flinty, reddish and greenish micaceous shale and flaggy sandstone are associated with whitish quartz-veined quartzites. Underlying Carboniferous marl and conglomerate in the west branch are white and red irregularly-bedded quartzite and slate, belonging apparently to the highest group. Some distance to the southward, between Keys Lake and Black River, the junction of the middle and upper groups is again recognized in outcrops of reddish quartz-veined slate, gray and greenish pearly slate, compact and fine-grained sandstone, and rusty-weathering gray slate and sandstone like those of South River (p. 55 P, line 14); and again, near Caledonia Mills, Hughie's Lake, and Alder River post-office, the rocks at all these places being spotted with specular iron ore. From Hughie's Lake **Fossil plants.** **Contact with Carboniferous.** **Junction of middle and upper groups.** **Iron ore.**

westward to South River, only a narrow belt of the green slate and hæmatitic sandstone or upper part of this group appears, the gray slates having been removed by faulting or denudation; it again widens in the direction of Goshen and Lochaber, and includes a great thickness of plant-bearing strata. The green slates, when in contact with masses of trap, are altered into a rock resembling soapstone or serpentine.

South River of Antigonish. The greenish and bluish-gray slate and sandstone near the foot of South River Lake are probably of the same age. On the east side of the lake, a great part of the road is occupied by blackish coarse diorite, **Diorite.** crumbling to a brown or rusty sand, and having altered the slate and sandstone with which it is in contact.

McPhee's mill-brook. At McPhee's mills, purple slates of the upper group occur. Immediately above the road a wild and beautiful rocky gorge shows quartz-veined white-weathering quartzite and purple slate, underlain higher up by bright-green and gray slates and flinty sandstones, sometimes graphitic, **Quartz veins.** containing large irregular masses of white quartz, **Iron ores.** covered with films and spots of specular iron. About a mile above the mills, soft greenish slates enclose small lenticular layers of brownish ferruginous limestone or ankerite, and in other respects strongly resemble the rocks of Guysborough Harbour (page 56 P). In the branches from the south, as already stated, the lower conglomerate comes nearly to the main brook. In the eastern branch of the large brook from H. McDougall's on the north side, reddish and greenish flinty slates, dip 161° < 79°, are veined with calcspar and quartz, and asociated with bluish-gray, micaceous, pearly slates, holding a very obscure *Psilophyton* and dipping 325° < 85°. In the branch to the westward these rocks show the same changing dip. The fact, therefore, that the slates and quartzites seen nearest the conglomerate seem often to dip under it does not prove that the former is older. **Pyritous veins mined.** The pyritous veins of these two brooks have been mined, and indications of specular iron also followed. Red slates follow the road to the westward, but conglomerate is in place 325 yards west of the road to Vernal. Red and green slates, with hard bands and rusty-weathering slate and sandstone, extend thence to John Chisholm's, being succeeded everywhere to the northward by the upper red slates.

South River Lake. From their contact with the upper group at McPhee's mills, greenish and gray slates run up South River and along the west side of South River Lake to Goshen. Near the outlet, and in the brook from the westward, they consist of yellowish, silvery and greenish-gray slates **Pyritous quartz veins.** and quartzites intersected by threads of quartz, full of pyrites and often micaceous. On the lake shore, below the church, gray quartzites **Iron ore.** with veins of quartz and specular iron, are interrupted by trap and diorite.

In Hattie's millstream, at the mill above the road, bluish-gray, very flinty slate dips 346° < 55°. The dioritic and syenitic rocks of this neighborhood are very crystalline and gneissic. At the Polson's Lake copper mine the detritus is dark slate, veined with quartz, which has been dug in one of the pits behind the main shaft; whereas in others it is the light-gray siliceous argillite, which in the outlet brook is associated with dark-gray argillite and micaceous sandstone, with impressions of fucoids. On the south side, at the foot of the marsh, is a hill of greenish-gray quartzite, greatly broken and spotted with specular iron, interstratified with wrinkled slate, veined with epidote, and probably in the vicinity of intrusive rock. On the hill further east, the wrinkled slates are composed of a mixture of quartz, felspar and hornblende, cut by dykes of black hornblende-rock. Blocks of these rocks extend to the outcrop of whitish marble, and nearly to the lake.

Hattie's millstream. Volcanic rocks. Polson's or Copper Lake copper mine. Fucoids. Marble.

On the road from South River Lake to Copper Lake, greenish slate and sandstone are again seen; to which, between Copper Lake and Lochaber, the upper red slates and quartzites succeed. At the lower end of Copper Lake, very dark, almost black, argillaceous sandstone, in thick and flaggy beds, contains geodes of specular iron. In the brook near Ireland Lake, reddish sandstone, flinty argillite and dark bluish-gray papery argillite, containing blotches of quartz, are in contact with gray and greenish trap and diorite, with threads of specular iron. Gray Devonian slate apparently occupies all the road through Goshen to the mill at Pringle Lake, where blocks of Carboniferous grit abound; and grit is unquestionably in place at the South River road. Out Tate's and McDonald's road to the eastward, Devonian slates are probably present past the first house and to the brook about 300 yards from the main road, beyond which Carboniferous rocks begin. There can be here no mistaking the change from Carboniferous to Devonian. On the road at the lake west of Pringle Lake, is a hill apparently of slate; but the boundary to the westward is obscure. In the brook which follows the road from Goshen to South Lochaber, however, gray and whitish slates and quartzites resembling those of Birchtown, Clinton and Pirate Harbour are well exposed and contain obscure fragments of *Psilophyton*. In a large branch from the southward is a quartzose conglomerate, with pebbles as large as a plum. In another branch are small bands of bluish shaly limestone containing specks of copper pyrites. They are first seen on the Sherbrooke road near the head of the little lake between Lochaber and Two-Mile Lake, but between this point and Sandy Lake are doubtful. Between Lochaber and the head of Two-Mile Lake the land is low and swampy. In Hattie's Brook, the first outcrops are whitish granular quartzite or

Iron ore. Goshen. Junction of Devonian and Carboniferous. Fossil plants. Limestone and copper ore. Lochaber and Two-Mile Lake

Hattie's Brook. altered grit, like that seen on the road to Goshen from the foot of Lochaber. At the end of the clearings, a thick band of gray, micaceous, fine sandstone is followed upstream by greenish shales or slates; and

Barrens. still higher by large outcrops of white flinty quartzite on barrens as rocky as those of Grand River. Above a small pond and haymarsh, is a cliff of greenish and gray, micaceous, fine, flinty sandstone, splintery, white-weathering, rusty in places and spotted, like the quartzites of Loch Lomond, with minute traces of specular iron in the joints. This outcrop is not far below Hattie's Lake, on the shores of which the rocky barrens end and there is a clearing on good soil. In the brook at the head of the lake, dark bluish-gray, flaggy and slaty micaceous argillite or very fine sandstone is followed by dark slates, underlain by greenish-gray, fine flinty sandstone and arenaceous shale, containing large scales of mica; and by white quartzite and grits, as far as Hugh

Country Harbour River. McMillan's clearing. In County Harbour River, above Eight Island Lake, gray, compact micaceous quartzite contains minute veins of

Argyle. quartz. On the roads south of Argyle, on that to Duncan McIntosh's and on those toward Goshen, similar rocks are cut by small dykes of

Junction of Devonian and Carboniferous. trap. About a mile west of Yellow Lake, the boundary of the gray argillaceous Carboniferous sandstone and Devonian slates is seen.

The rocks of Erinville and Salmon River have already been described. The higher green strata are not seen, being probably covered by the Carboniferous. At the contact near the confluence of the north branch, the difference between the Devonian micaceous sandstone and bluish-gray wrinkled slate and the overlying Carboniferous sandstone is as unmistakable as at Pringle Lake.

Lochaber. The contact between the upper red slates and green slates is well seen on the roads in Middleton, at the foot of Lochaber, and on the west side of that lake, the latter being associated with dark bluish-gray, pearly, friable slates, like those of Copper Lake, and with rusty-gray

Traces of iron ore. argillite and sandstone, spotted with specular iron and veined with calcspar or ankerite. The dip is south-easterly or north-westerly at a very high angle.

Devonian and Carboniferous in Boggs Brook. In Boggs Brook, near the head of Two-Mile Lake, not far above the road, are reddish and greenish flinty sandstone and grit, probably Carboniferous. Higher up, at the picturesque old saw-mill, are flinty grits like those on the Goshen road and at Hugh McMillan's, perhaps also Carboniferous; but in a small branch above the road are dark bluish-gray, papery Devonian slates, succeeded in the main brook by coarse rocks, probably Upper Devonian.

Silurian and Devonian of McNab Brook. Further north, McNab Brook traverses both the middle and upper groups near their contact with the Silurian. Near the road, the red argillites and quartz-veined quartzites of the latter form cliffs with

a series of falls and cascades of great beauty. At the top of the falls, where the brook approaches the track to Murphy's, gray shales contain *Psilophyton* and obscure ferns. Downstream, the few outcrops indicate the usual succession above these shales—greenish and cream-coloured pearly slates, with veins of quartz, sometimes eighteen inches thick, which contain chlorite but no metallic matter, overlain by red slates. The slates upstream, where the brook crosses the track, are obscure, and may be either Devonian altered by traps, or older. The greater part of this track is in the greenish slate found everywhere in the neighborhood from Peter Murphy's eastward to the little lake and north-eastward to the head of Callahan Brook. Where Callahan Brook becomes rapid, compact, flinty, splintery, greenish and bluish-gray slates form cliffs, down which the water tumbles tumultuously twenty-five feet in cascades and a fall, which have cut a ravine with walls more than fifty feet high, through the mouth of which a man can barely squeeze. If the slates are, as above suggested, Devonian, the light-colored and reddish compact and granular quartz-felsite and syenite of the neighborhood would seem to be newer and intrusive.

Fossil plants.

Quartz veins.

Callahan Brook on West River Antigonish.

Age of the volcanic rocks.

Overlying the felsites in Jordan Brook are highly graphitic slates, so black as to have been dug for coal; followed downstream by white, flinty quartzite, like that of the Goshen road, and by quartz-veined, pyritous dark slate and bluish-gray, flinty, micaceous sandstone and grit. About twenty yards below the fork above the settlement is an exposure of greenish-gray slate; while flinty, purplish altered sandstone, perhaps Carboniferous, is found along the west side at the settlement. In McKay Brook, also, above the St. Mary's road at the tannery, bluish-gray and black slate occurs, as well as in the country to the eastward.

Graphitic slates mined for coal in Jordan Brook, East R., St. Mary's.

McKay Brook.

The northern boundary of the Devonian belt, which extends along the East Rivers of St. Mary's and of Pictou, is well defined, whereas the junction with the Carboniferous on the south is often obscure, owing partly to the barren, unsettled character of the country, and partly to the similarity of the gray slates and quartzites to the shales and sandstones derived from them. In general, however, this boundary, as shewn on the map, may be taken as correct; it is seen more or less distinctly on the track which runs westward through the barrens from Newtown, as well as in the various brooks. In this belt none of the greenish pearly slates seem to occur, nor the red rocks of the upper group.

Southern boundary of Devonian and Carboniferous obscure.

From the confluence of Black Brook, flinty, coarse, white glassy quartzite, like that of the Goshen road, the foot of Lochaber, Grand River and Clam Harbour barrens, extends in fine cliffs for some distance up the East River of St. Mary's. The flinty quartzite and

East River of St. Mary's.

dark argillite of the road to north and east belong probably to this group, and for a great distance to the westward the road forms the boundary. Immediately south of David A. Sutherland's, barrens as rocky as those of Grand River show blocks and outcrops of coarse, quartz-veined, rust-spotted grit or quartzite, well seen also in Sutherland's Brook, below the fork of the branches from Long and Elbow Lakes, associated with gray argillite, breaking into irrregular pieces a foot long and two inches wide. At the fork, gray and bluish-gray crumbly slates contain obscure *Stigmaria* rootlets, and are overlain by thick beds of white-weathering, flesh-red and white grit or quartzite, containing quartz-veins, seldom large, running in all directions and very numerous. Immense ledges of quartzite occur in various parts of this district and around the lakes. The cliffs at the cascades below the fork mentioned above show gray, fine argillaceous micaceous sandstone, mixed with the finest and most flinty quartzite, flecked with specular iron in the joints. In the branch from Gunn Lake, and again, above this lake, are ledges of white, glistening Grand River quartzite, varying from compact to coarse, pebbly grit, breaking into innumerable, irregular, angular pieces, usually smaller than a hen's egg, and fit for macadamizing roads. In Sutherland's Brook, the first rocks of the cliffs at the cascades below this branch are greenish-gray and gray flinty sandstone and slaty argillite, the more shaly portions, particulary the gray beds, yielding fragments of plants. Fine, micaceous, quartz-veined sandstone, and red and green mottled argillite, flinty grit or quartzite, with lines of jointing that might be mistaken for bedding,—in alternate thin bands, or in great masses, sometimes finely rippled, but generally splintery and difficult to examine,—are succeeded lower down by bluish and greenish-gray, smooth-bedded, micaceous argillaceous shale, interstratified with fine-grained, micaceous, quartz-veined sandstone and grit, and with layers of dark-gray graphitic shale, from which Mr. Weston collected a large number of badly-preserved plants, which resemble rhizomes of *Psilophyton*.* In a bed of white, flinty, coarse quartzite, not far above the confluence with East River, is a fine *Stigmaria*, surrounded by graphitic matter. The quartz-veins carry a small quantity of ankerite. Similar outcrops occur both above and below the confluence in East River, are also displayed in unbroken cliffs in the gorge above Campbell Brook, and below the Garden of Eden pass into a nut-conglomerate, forming the walls of the gorge with its nearly vertical beds. As exposed everywhere about the lakes south of East River, these rocks present no features of special interest; their dip is indicated on the map. The strong resemblance to the Dadoxylon sandstone of New Brunswick scarcely needs to be again pointed out.

Sutherland's Brook.

Fossil plants.

Quartz veins.

Trace of iron ore.

Fossil plants.

Graphitic shales.

Ankerite.

East River of St. Mary's.

Similarity to NewBrunswick Devonian.

*Determined by Sir J. W. Dawson.

Bare ledges of white quartzite and flinty conglomerate, with large pebbles of white quartz, occur in the barrens southwest of the Gut and of Beaver Lake, and strike across the road from Sunnybrae to Caledonia. The gray, shaly and flaggy graphitic quartzose rocks west of the head of Eden Lake are probably of this age. **Eden and Beaver Lakes.**

In the East River of Pictou, below Kerrowgare, bluish-gray and blackish, contorted, pyritous, graphitic, polished slates, greatly broken, contain veins of a rusty mixture of calcspar and quartz resembling those of Roman Valley and of Deyarmond's at Pembroke, near Stewiacke River. They strike down the river, and are seen in other brooks from the southward. In the mill-brook, a mile and a half above Sunnybrae bridge, they are exposed at the mill, too much cleaved to yield fossils, but succeeded in cliffs higher up by quartzite, sandstone, and grit, interstratified with bands of greenish and bluish-gray micaceous slates and flags, containing numerous markings of *Psilophyton* allied to *P. glabrum* and *P. elegans*, and obscure *Cordaites*.* In the branch from the westward, these strata are associated with greenish and reddish soft shales, spotted with hæmatite; in places the sandstones are traversed by veins of limonite, one of which, about four inches thick, cuts across the stratification, is mixed with sandstone into a sort of breccia, and throws threads through it. Black slates are found in other branches of the East River, nearer Bridgeville, but have not yet been examined. **East River of Pictou. Graphitic slates.** **Sunnybrae.** **Fossil plants.** **Hæmatite and limonite.**

The track from Sunnybrae to Archibald Cameron's house, at the West River of St. Mary's, crosses good exposures of Devonian rock, about a mile south of Peter Cruikshank's house, where they consist of white quartz-veined quartzite, bluish-gray micaceous slate, and spotted red and green slate, the quartzite being cut by small veins of limonite, and stained blood-red, as in Sutherland's Brook. The country is more or less barren throughout, covered with blocks of quartzite, which has sometimes a slight pink, sometimes a bluish-gray or purple tinge. The greenish-gray, flaggy, micaceous sandstones, near the logging-camp, at the crossing of Bryden Brook, with gray and rusty layers, full of comminuted plants, are probably still Devonian, although immediately beyond, the blocks of gray conglomerate are Carboniferous. **West River of St. Mary's.** **Iron ore.** **Barrens.** **Junction of Devonian and Carboniferous in Bryden Brook.**

On the roads about Trafalgar, toward Lorne, and in the vicinity of the French settlement north of Ellen Brown's Lake, slates and quartzites underlie rocky barrens of great extent, very little of the land being fit for cultivation. At West Branch Lake, however, blackish slate begins, and the country is better. Near Nelson's, they are overlain by Carboniferous rocks, a belt of which extends down the **Trafalgar and Lorne.** **Junction of Devonian and Carboniferous at Trafalgar.**

* Determined by Mr. Ami.

West River, having the granite and whin of the gold-bearing series on the south.

Devonian rocks on the railway in Colchester county.

Along the Intercolonial railway, from West River station, about $31\frac{1}{2}$ miles from Pictou, westward to beyond the 33rd mile-post, only a few blocks of white-weathering sandstone and greenish quartzite are seen. Then begin smoothly-bedded, gray argillites, with bands of rust-spotted flinty sandstone, full of *Cordaites;* and still further west, overlying these, are gray shale and sandstone, containing prostrate trunks of trees, the sandstone predominating. These are precisely like the rocks of the barrens near the Garden of Eden, and are overlain by similar rocks, interstratified with layers of red and green crumbly shale, and thin bands of dark shale, containing plants and trees. Good exposures of reddish and greenish shale and sandstone, having occasionally the texture of underclay, are found near the 34th mile-post; these rocks are not unlike the Carboniferous rocks near Wallace bridge and include blackish and gray argillite, with layers of flinty sandstone, About 300 yards west of the 34th mile-post is a cliff of blackish carbonaceous shale, full of small hollow concretions of iron-stone in numerous thin layers, seldom exceeding half an inch in thickness, the intervening layers of cordaite-shale being from one to two inches thick. Above these follow flinty, ochre-spotted grit, quartzite and shale, succeeded by red and greenish shale, with bands of quartzite, at the 35th mile-post. From these rocks Messrs. Weston and Robert collected *Lepidodendron corrugatum, Stigmaria ficoides* and stipes of ferns.* They extend to the westward in rocky barrens, and include a band of siliceous underclay, with *Stigmaria* and erect trees. The highest strata occur at the siding and 36th mile-post, the dip varying from $316° < 53°$ near West River to $355° < 68°$ at the top. If the sequence is unbroken, as seems probable, the thickness cannot be less than 6,065 feet, nearly all of which is exposed, the railway running nearly due west. For about a mile and a half further, these rocks are repeated; they are then obscure, the dip being reversed at an angle of 80°, at a probable fault, but decreasing again to 40° near the 39th mile-post, where the ironstone band again reappears, and the measures are again troubled for some distance. About three-quarters of a mile east of Riversdale station is a band of greenish and gray crumbling, impure, rubbly limestone, quartzite and calcareous shale, from the vicinity of which Messrs. Weston and Robert obtained a new species of *Calamites* of great interest, with leaves and fruit, and a *Sphenopteris*.† With the plants are also found at many places good specimens of *Anthracomya*

Fossil plants.

Carbonaceous shale, with iron-stone nodules.

Fossil plants.

Barrens.

Ironstone.

Riversdale.

Limestone.

Fossil leaves and fruit.

Shells.

* Determined by Sir J. W. Dawson.

† Determined by Sir J. W. Dawson, who considers the rocks as probably Lower Carboniferous or Millstone Grit.

(*Naiadites*) *elongata* and *A. lævis*. At the 40th mile-post, half a mile west of Riversdale, the dip is $161° < 60°$, at the beginning of a continuously ascending section, which shows 3,531 feet of alternations of gray and brownish flinty quartzites and slates, forming a very barren country, and no doubt a repetition of the section* east of Riversdale; overlain by 6,468 feet of red beds of the upper group, the summit of which is reached at the shanty, half a mile west of Union station. Beyond the shanty these upper beds are, for a mile and a half, repeated in descending order; they are then folded or troubled, covered on the line of the railway by red rocks of Triassic age, but run on a ridge south of Truro, where they were recognized by Dr. Ells.† **Red rocks of the upper group at Union. Contact with Triassic.**

On the road south from West River station are gray shales and sandstones like the foregoing; dark argillite and quartzite, containing quartz-veins and minute seams of ankerite in the joints. **Devonian of Stewiacke.**

Upper Red Slate and Sandstone Group.

The rocks of this group, on the rocky barrens along the railway, consist of red or brownish shales or slates, with bands of quartzite or flinty quartzose, glistening sandstone. As they have been examined only on the railway, on a road between Truro and Stewiacke, and on another between Pembroke‡ and Riversdale, they will not be again referred to at present.

Upper Devonian rocks underlie the Carboniferous in another large area between upper Tracadie and the College, west of Lochaber; a third extends from Arisaig to Bailey's Brook.

Upper Devonian of Tracadie and Lochaber.

On Tate's road (sheet 22), from the contact of the Carboniferous, west of Grosvenor, red and purple quartzites and argillites extend to the old post road. To the westward, on this road, are greenish and gray rocks, probably at the top of the middle group. Purple and red slates also occur on the Mathy road. In Tracadie River, at the Salmon Hole, is a flinty, reddish-gray sandstone, perhaps Carboniferous, and lower down, greenish flinty grit, traversed by minute threads of quartz, and passing into nut-conglomerate. If, as seems probable, these represent the strata of the "big cut" on the railway (page 71 P), a tongue of Carboniferous conglomerate would seem to run up this valley to the bridge at the post-office. **Carboniferous and Devonian of Tracadie.**

* Acadian Geology, Supplement, p. 48, l. 30.
† Geol. Survey Report for 1885, p. 50 E.
‡ Acadian Geology, p. 560, l. 40.

Monastery Brook.

At Breen's mill, on the Monastery Brook, reddish and greenish-gray glistening sandstone or quartzite is associated with softer, shaly beds, and overlain by Carboniferous limestone and red soft marl.

Black River of Pomquet.

At Backlands, Fraser's Grant and New France, red slates and quartzites abound on the brooks and roads. In Black River, below the old road, gray flinty argillite, dipping $111° < 50°$, is underlain at the post road by red argillite and quartz-veined sandstone. Lower down, a belt of greenish slate shows a south-easterly dip; but the prevailing rock is red argillite. In the tributaries from Fraser's Grant, and in the main river below them, red argillite, having a south-easterly cleavage-dip, and greatly jointed and broken, rises into rough, picturesque crags. The harder bands, interstratified with the argillites, alone mark the dip. The river is almost continuously rocky, in gorges, with cascades and falls for several miles, and exposes layers of white, flinty, quartz-veined quartzite among the prevailing red; below which, crumbly red and green soft shales and sandstones, with thin bands of rusty limestone, indicate the beginning of the Carboniferous basin, the contact of which is again seen in Pomquet River, not far above the bridge at Meadow Green, where the Blue Cape limestone and associated strata rest upon reddish flinty sandstone, rusty-weathering quartzite, and red argillite or slate, veined with quartz, and well exposed near Beauly.

Contact with Carboniferous.

South River and Lochaber.

Red or purple rocks, more or less argillaceous, are displayed in the South River of Antigonish for three hundred yards below the bridge at Fraser's mills; mounds then indicate the probable crossing of Carboniferous limestone. In the brook along the road to Lochaber, blocks of red argillite occur, and outcrops are found in all the brooklets from the southward. Where the road turns away from the brook, red slate is in place thirty yards above an old mill, with Carboniferous limestone one hundred and fifty yards to the westward. Above Fraser's mills, red or brown, scaly, micaceous, quartz-veined argillites are seen in South River and all its branches, as well as in the brooks running to Lochaber, the veins holding chlorite and crystals of transparent quartz. On the road from Copper Lake to Lochaber, the bluish-gray and greenish rocks of the middle group are overlain by red and purple shales containing a little specular iron.

Contact with Carboniferous.

Iron ore.

In the brook at Lochaber chapel, pearly, soapy slates, of the usual shades of red and purple are continuous to the top of the hill, where they are underlain by gray, bluish-gray and green slates of the same character, resting in turn upon greenish and gray quartzites holding specular iron in the joints and veins.

On both sides of Lochaber, red and purple and dark bluish-gray

slates and quartzites are well exposed, associated on Crockett Island* with green slates and a band of Arichat conglomerate.

In Hurlbert Brook at the saw and grist mills, a fall thirty feet high cuts through red slate and quartzite, dipping about 100° < 50°. Above the fall, the brook is rapid for some distance, then opens out into a marshy lake and chain of alder-marshes and ponds, above which is a fork. In the northwest branch, red slates dip 111° < 69°, turning more to the south higher up. Red slates are in all the neighboring brooks.

In the little brooks near the foot of Lochaber, on the west side, red and purple slates and sandstones, quartz-veined, broken by joints and containing traces of specular iron, rise into fine cliffs.

The rocks of McNab Brook have been already described. On the track from Peter Murphy's to Lochaber, the blocks of reddish altered sandstone which abound with others of greenish pearly slate, belong apparently to this group.

Lochaber copper mine.

Near the copper mine at the College, reddish sandstone and argillite are found not far from fragmentary rocks, perhaps Pre-Cambrian; while at the mine, a greenish granular diorite is associated with copper ore, mixed with a large quantity of specular iron. On the road north of Angus Cameron's, Devonian argillite is cut by intrusive rock.

Boggs Brook.

Down Boggs Brook, below the little lake, reddish-gray, fine, flinty sandstone and smoothly bedded argillite, with a few veins of quartz, are succeeded by flinty, reddish-gray sandstone and fine, white silicoons rock, weathering cream-colored and streaked with threads of quartz, well exposed at a cascade. At another, are cliffs of reddish-gray coarse, flinty grit and fine conglomerate, with minute veins of quartz, passing into coarse conglomerate, with blotches of specular iron and beautiful crystalline aggregations of quartz.

Iron ore.

The gorge with cascades near the foot of the rocky portion is cut through flinty, fine sandstone, grit and conglomerate, the thickness of which must be considerable. Conglomerate also crosses the road north of the foot of the lake about one hundred yards from the lake road; it is cut by veins of quartz, and is so unlike the red-slate group, and so like that at the base, that it will possibly be found to be a recurrence of the conglomerate of the east side of South River Lake (p. 54 P).

At William McDonald's and at John Carroll's, red and purple slates are abundant. On the track between Carroll's and Garvie Lake, felsites appear.

Upper Devonian Rocks of Arisaig and Bailey's Brook.

Age as defined by Honeyman.

Of these rocks, at McAra's Brook, Dr. Honeyman says:† "They are certainly not Lower Helderberg, and may, therefore, be Devonian . . .

* Trans. N. S. Inst. Nat. Sc., Vol. IV., p. 76.

† Trans. N. S. Inst. Nat. Sc., Vol. III., p. 13.

Upon these, the lower Carboniferous conglomerates lie unconformably, . . . the line of junction being behind a mass of amygdaloid." By Sir J. W. Dawson, they are also apparently regarded as Pre-Carboniferous,* although not separated from the Silurian.

By Dawson.

McAdam Brook,

Succeeding a synclinal of Lower Helderberg strata, in McAdam Brook,† is a great thickness of indian-red and reddish-gray soft slate and calcareous, micaceous sandstone, cut by veins of white barren quartz, with vugs holding crystals of quartz, which are found in nearly continuous outcrops for about half a mile, and beyond this point, at intervals, as far as the Hollow ("Bruin's Highway"), interstratified with a few feet of greenish-gray micaceous quartzite, showing obscure remains of plants.

The Hollow.

Stonehouse Brook.

About 183 paces west of Stonehouse Brook, on the shore road, these rocks dip 183° < 20°, but are variable. Stonehouse Brook and the head of Joseph McDonald's Brook present exposures, principally of red slate. Good exposures are also cut by McAra's Brook, behind the mass of amygdaloid at the shore, consisting of red, flinty, micaceous, jointed sandstone and slate, often concretionary, interstratified with greenish thick-bedded and flaggy sandstone, containing traces of carbonate of copper and iron pyrites; the brook being rocky up to the shore road. From the latter, a collection of fossils was made by Mr. Weston, comprising fragments of plants and fish-teeth, not certainly determinable, together with certain interesting footprints like *Protichnites carbonarius*.‡

McAra's Brook

Copper.

Fossil plants, fish and footprints.

Devonian rocks, broken by dykes, are found as far as the head of this brook, on the road to the Hollow, in all the district from the Hollow northward, in the valleys of Dunmaglass, but rising, also, into high peaks among the hills. Downstream in Knoydart Brook, below Dunmaglass, they are admirably displayed in a clean, beautiful valley, with either a rocky or pebbly floor, contained by mural crags or steep, mossy slopes, from which the trees meet overhead. The red argillites are so greatly cleaved and jointed that the dip can be obtained only on the few accompanying bands of reddish and bluish-gray fine sandstone; they are cut by dykes of fine calcareous diorite, are sometimes spotted green, contain greenish, concretionary, hard bands and nodules, are seldom pearly like the red slates of Lochaber, and are unconformably overlain by Carboniferous strata, the junction being plainly seen above John McGillivray's mill.

Dunmaglass.

Knoydart Brook.

Dykes.

Contact with Carboniferous.

The boundaries of the different formations, closely traceable here and towards Ardness by excellent outcrops, are shown on the map.

Ardness.

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* Acadian Geology, p. 316, line 4, and Supplement, p. 49, line 15.
† Trans. N. S. Inst. Nat. Sc., Vol. IV., p. 56.
‡ Supplement Acad. Geol., p. 55.

In the brook from the southward at Ardness post-office, soft, reddish Carboniferous conglomerate and marl are succeeded immediately above the road by red, calcareous, concretionary Devonian argillite. This extends, with occasional greenish bands, to the Hollow, on the slope of which the dip is $300° < 10°$ at the contact of layers of sandstone and argillite, while the dip of the cleavage, replaced by lines of jointing nine inches apart in the sandstone, is $204° < 70°$, and might easily be mistaken for bedding. Near Vamey's Brook, red slates surround the hill of Silurian rock, and high ridges on the east side of the brook show cleavage planes running 246° to 271°. **Vamey's Brook**

The reddish-gray fine sandstone, underlying Carboniferous limestone, in the east branch of Bailey's Brook, is probably Devonian. It is succeeded upstream by brick-red argillite, and still higher, by traps and Cambro-Silurian slates. **Bailey's Brook.**

The red siliceous hæmatitic rock at Avondale post-office may also be Devonian. **Avondale.**

G. Carboniferous.

The general distribution of the groups which contain all the Carboniferous strata exposed in this region is given at page 7 P of this report.

These groups are:

G 1m. Carboniferous Conglomerate.
G 1. do. Limestone.
G 2. Millstone Grit.

G 1m. Carboniferous Conglomerate.

The rocks of this group resemble those described in previous Geological Survey Reports* and shown to lie unconformably to the Carboniferous limestone. This unconformity, as seen at the Strait of Canso and Antigonish, at Lake Ainslie, Margaree Forks and other places† is not merely local, as stated by Sir J. W. Dawson,‡ and the supposition|| that "a portion at least of this division is probably contemporaneous with the Carboniferous limestone formation" can be regarded as true of only a small portion of it. The great difference of thickness in so many places in adjoining areas cannot, in the absence of faults, be ex- **Unconformable with the Carboniferous limestone.**

* Geol. Survey Reports for 1875-76, p. 394; for 1876-77, p. 437; for 1877-78, p. 23 F, and for 1882-83-84, p. 37 H.
† Sheets 11, 13, 14 and 22 of Report for 1882-83-84.
‡ Supplement to Acadian Geology, p. 102.
|| Geol. Survey Report for 1876-77, p. 437.

plained otherwise than by unconformity similar to that found in New Brunswick, and noticed by Mr. Robb, Mr. Brown and Professor Hind* in Cape Breton. The whole series of Lower Carboniferous rocks in New Brunswick is considered at page 354 of the Report for 1876-77, and an unconformity between two of the divisions described on page 355. In the Report for 1878-79, page 16 D, the question of the age of the Albert shales, which correspond with this lowest Carboniferous group at the Strait of Canso, is discussed, and also their relation to the Devonian; and in the Report for 1885, p. 33 E, a section is given, subdivisions 1, 2, 3 and 4 being of this group.

Similarity to the Albert shales.

Distribution.

The principal areas of this formation are: 1. At Tracadie and Harbour Bouché. 2. On the peninsula north of Antigonish. 3. At McAra's Brook. 4. In the long trough extending from Salmon River Lakes to Trafalgar.

1. *Basal Carboniferous Rocks of Tracadie and Harbour Bouché.*

North Canso.

The strata of North Canso are described in the Report for 1879-80, p. 61 F, and in the present report at page 50 P. At the lighthouse, reddish-gray argillite and flinty sandstone resemble the Devonian strata of Union station. In the little brook, up which the shore road climbs, a mile east of the head of Harbour Bouché, the reddish and gray soft shales and fine, micaceous sandstone are perhaps the same as those found in the railway cuttings east of the station. About one hundred and fifty yards west of the school, very flinty rocks, probably Devonian, are on the road and in the hill to the south; but two hundred yards from the school, Carboniferous argillite is again on the road, indicating an irregular boundary.

Little Tracadie.

The land about the head of Little Tracadie Harbour, from T. W. Kinney's to John Chisholm's Brook, is very rocky with reddish-gray, coarse, crumbling Carboniferous grit and conglomerate. On Tate's road, at the railway crossing, these rocks become much more coherent, and contain blotches and veins of quartz; and some distance south of the crossing are underlain by red Devonian slates and flinty quartzites, the former perhaps representing the first rocks seen on the shore of Harbour Bouché, which are also traversed by quartz-veins, and underlain by light and dark-gray papery shales, crenulated on the strike, passing into pure limestone and including flinty bands of greenish rippled sandstone, jointed into small pieces, covered on some surfaces with shrinkage marks and containing concretions of compact limestone; these occupy the shore for about half a mile south-east of the lighthouse, and are, according to Sir J. W. Dawson, the equivalent of the Horton shales.

Quartz veins. Contact with Devonian.

Black shales and limestone.

* Geol. Survey Reports for 1872-73, p. 173, and for 1882-83-84, p. 45 H.

At the grist-mill, north of the 67th mile-post, are indefinite outcrops of greenish-gray, flinty, fine grit and reddish conglomerate, blotched in the joints with quartz and associated with fine argillaceous sandstone and shale. Similar rocks, found in Little Tracadie River and other brooks of the neighborhood contain pebbles of red syenite, whitish quartz-felsite, red fine sandstone and compact, quartzose grit or quartzite, often as large as a goose's egg. On the railway, near the 66th mile-post, are reddish-gray fine sandstone and argillaceous shale, not unlike the strata of Janvrin Island and Hawkesbury. In the "big cut" between Tate's road and Little Tracadie River, and also south of the railway on the roads to the eastward, are greenish, very flinty, quartz-veined grit, conglomerate, quartzites and purple slates, which perhaps indicate a passage to the Upper Devonian. Reddish crumbling argillite, at the crossing of Little Tracadie River, and again nearer Harbour Bouché, is associated with greenish flinty sandstone and grit or quartzite. At the 70th mile-post, reddish sandstone and argillite are found; while still further east are rocks unmistakably Devonian—gray quartzites and bluish and greenish-gray slate. **Conglomerate.**

The flinty, coherent grit and argillite, immediately above the second mill and underlying the limestone in Monastery Brook, probably belong to the base of the Carboniferous rather than to the Devonian. They end about half a mile upstream, being underlain by the gray slates and sandstones, from which fossils were collected by Mr. Weston. **Monastery Brook.**

2. *Basal Carboniferous Rocks of the Peninsula north of Antigonish.*

The rocks in this area are precisely like those described above, except that, in addition, there are found small seams of coal or black bituminous shale, which have been, to a small extent, worked; the conglomerate is, as a rule, also more friable, although, in several places, cut by dykes of igneous rock; it everywhere underlies unconformably the limestone and plaster of the next higher group, and is well exposed in the brooks and on the shore. **Coal.** **Dykes.**

Indian-red coarse conglomerate and sandstone, and red and green marl, apparently of great thickness, occupy a broad belt in Ogden Brook, associated with gray beds containing coal. On the shore, near Cribbean's Head, the conglomerate which overlies the Cambro-Silurian strata is red, gray and greenish, friable and thick-bedded, with bands of reddish argillaceous shale and rusty sandstone, enclosing fossil plants and trunks of trees. **Ogden Brook.**

North of Lakevale, similar rocks, often calcareous, contain layers of blackish argillaceous shale, and red and green shale, but the prevailing **Black shale.**

rock is conglomerate, composed of pebbles of great variety—of diorite, syenite, porphyry and greenish Cambro-Silurian slates, quartz-veined grit, conglomerate, and all the Pre-Carboniferous rocks hitherto described. Further north, blackish-gray sandstone and conglomerate, full of large scales of silvery mica, come in contact with reddish porphyritic trap, and are covered by twelve feet of reddish, impure, concretionary limestone, overlain by red marl, conglomerate, and other fine, concretionary layers; and, still further north, by limestone. A short distance south of Ballantine Cove, coarse conglomerate, reddish fine sandstone, and a bed of underclay, containing *Stigmaria* and carbonized plants, are cut by trap dykes, the conglomerate being noticeably altered only at the immediate contact, but containing minute veins of white calcspar, which also fills most of the cells of the amygdaloid. Some of the pebbles of the conglomerate are easily recognized fossiliferous Silurian rocks, while among them is also a whitish and light-colored saccharoidal limestone, like that of Georgeville. The extent of this formation about the cove is indicated on the map. The conglomerate of the cliffs on the steep, rough shore to the northward contains pebbles three or four feet in diameter, and is cut by threads of calcspar, which cross both pebbles and matrix; it can be easily examined at low water, the reefs extending one hundred yards from the base of the cliffs; it forms the steep point of Cape George, extends to Indian Brook, and beyond the Silurian bosses is largely composed of pebbles and blocks of this series, including syenite and diorite, sometimes several feet in length, in a matrix of reddish nut- and egg-conglomerate. Further south-west, the conglomerate is nearly vertical and overturned, much more coherent and gray, passing into coarse pebbly grit, and running in unbroken cliffs to Livingstone Cove, where it overlies Cambro-Silurian slates and conglomerate, of the detritus of which it is there in great part composed.

Dyke. Limestone. Ballantine Cove Underclay. Cape George.

In Dawson's Acadian Geology (p. 346) is a description of a number of fossils collected from Cape George, by Dr. Honeyman: *Lepidodendron corrugatum*, *Cyclopteris Acadica*, *Acrolepis* and *Palæoniscus*. The shales from which they were obtained, are said to be precisely similar to those of Horton Bluff, and "similar shales occur further to the westward, holding the same fossils, and are stated to be so rich in bituminous matter that hopes are entertained of utilizing them as a source of coal-oil.* The beds....in Right's River are probably of the same age. In the vicinity of Morristown there are red sandstones, conglomerate and gray sandstone, the latter containing *Calamites*, *Sternbergia*, and other coal-formation fossils, and, no doubt, higher in

Fossil plants and fishes. Coal oil. Right's River and Morristown

*Cf. also Trans. N. S. Inst. Nat. Sc., Vol. IV., pp. 70 and 455.

the series than the beds last mentioned." As already stated, these beds seem rather to belong all to the same group, and to underlie the Carboniferous limestone. Near Ogden Pond and Lakevale,* pits have been dug for coal in black bituminous carbonaceous shale, associated with grit and conglomerate; gray, rusty-weathering, micaceous shale and flaggy, false-bedded sandstone passing irregularly into the coarser beds and containing broken plants. Several large trunks of fossil trees, having the bark converted into coal, have also led to the search for coal on and near the shore in this vicinity. In one of the beds of gray coarse sandstone, a seam four or five inches thick, but only six feet long, tapers to a point at both ends, being probably derived from a large fossil trunk.

Coal formation fossils (?)

Coal pits.

On the Beaver road, gray and reddish mottled micaceous sandstone and shale are again interstratified with black bituminous shale, worked for coal. Sometimes the sandstone is nearly white, weathers rusty, and passes into gray grit and conglomerate. The red and the gray conglomerates seem to be the same, for one is always near or mixed with the other. On the highland of Cape George, the red calcareous variety is always present, and usually also in Ballantine Brook and the other northern streams, passing in places into limestone-breccia and traversed by minute veins of calcspar.

Conglomerate.

On the barrens or commons about Greendale, Heffernan Marsh and Malignant Brook are good outcrops of bluish and greenish-gray coarse sandstone, grit and conglomerate, like those of the shore. In Graham or Sinclair Brook,† the coarse rocks are associated with mottled, reddish and greenish sandstone and marl, containing plants; and in the branch called Walsh Brook, with dark bluish-gray shale.

Barrens.

The land about Cape George is very fertile and well settled, although high, being underlain by calcareous conglomerate. The glens of the Cape are singularly beautiful. In Malignant Brook, at the bridge, a mile and a half above the mouth, the Carboniferous sandstones and conglomerates are more altered than those just described, which is perhaps due to the amount of folding and tilting to which these rocks have been subjected. The land along the road up the east side from this bridge is not thickly settled, the soil being for the most part rendered too rocky for cultivation by blocks and outcrops of gray sandstone and pebbly grit, sometimes quarried for rough work in building. In the brook, good exposures begin not far below the sawmill at Maryvale, fine and coarse, thick-bedded and flaggy, gray sandstone and conglomerate, very micaceous and like the rocks of the St. Mary's Car onifer-ous basin, containing, among others, pebbles of red syenite, and of the

Malignant Brook.

Barrens.

Quarries.

*Acadian Geology, page 349.
†Trans. N. S. Inst. Nat. Sc., Vol. IV., p. 69, and Vol. VI., p. 318.

red Cambro-Silurian grit of Malignant Cove. Near the mill, black, pearly, polished, graphitic, argillaceous shale has been dug for coal, and is interstratified with dirty greenish-gray and gray soft micaceous argillite, coarse grit and flaggy sandstone. Upstream, some of the rocks are so flinty, slaty, jointed and broken that, at first sight, they might be mistaken for Cambro-Silurian; the associated conglomerate also weathers very much like that of Malignant Cove, but is not so flinty, and is, moreover, interstratified with reddish fine grit, shale and rippled, micaceous sandstone. At the mill, comparatively soft, crumbling conglomerate is associated with black shale. In the north branch of Malignant Brook, above the road to the backlands, are outcrops of gray micaceous sandstone and conglomerate, sometimes nearly compact, thick-bedded, jointed and flinty, like quartzite, which, toward the Heffernan Marsh road, hold the black shale in which coal was sought. The same association of flinty rocks with more crumbly strata has been frequently pointed out in this formation. Some of the beds of gray, brown or rusty-weathering sandstone could not be distinguished from Millstone Grit; but, there is no evidence that all these rocks do not underlie the limestone of Hallowell, Grant, Lakevale and Antigonish. Immediately above the bridge at Maryvale, greenish-gray fine sandstone, cut by minute threads of calcspar, is followed by three feet of black, calcareo-bituminous, graphitic shale, breaking with smooth, polished faces so as to resemble coal, and cut in all directions by threads of calcspar, associated with greenish crumbling argillite and massive, gray, coherent, coarse and fine sandstone and grit, containing spots of coal and impressions of *Lepidodendron*. On the old Gulf road, black shale detritus is abundant near the head of Malignant Brook.

Coal pits.

Resemblance to Millstone Grit.

Black shales and coal.

Fossil plants.

At the bridge on Right's* River at Murphy's mills, fine exposures of reddish crumbling nut- and egg-conglomerate, dark shales and patches of fine sandstone are interstratified with small bands of limestone, and contain *Lepidodendron*. Up the eastern branch are outcrops of bright-red conglomerate confusedly bedded; and also on the road between North Grant and Pleasant Valley, running up the valley far above the sawmill on the Eigg Mountain road. A thickness of several thousand feet of strata is displayed in these brooks, unless there is some repetition by faulting; while at other places, as at Williams' Point and the limestone quarry on the old Gulf road, the conglomerate is altogether absent, and the limestone rests directly upon Pre-Carboniferous rocks.

Right's River near Antigonish.

Thickness.

In the little branch at the Clydesdale school, the conglomerate, which is for the most part calcareous, is stained green with copper, and

Clydesdale.

Copper ore.

* Acadian Geology, Supplement, p. 49.

interstratified with a band of dark calcareous shale or impure limestone, at least six feet thick; it is unconformably underlain by greenish flinty argillite and gray sandstone, holding pebbles of these rocks, one foot and less in diameter. Limestone.

The conglomerate found in the brooks north of the railway west of Murphy's mills, in a narrow belt underlying the limestone, requires no special mention: it is reddish, friable, of variable texture but usually coarse. The same may be said of the outcrops in Beaver River, Hartshorn Brook and Ohio River, which include, as usual, patches of fine sandstone and marl, among coarse beds, with pebbles three feet long. Contact with the overlying formations.

Large blocks of this conglomerate on Beaver River above the branch from McEachern Lake, indicate perhaps an outlier among the older rocks. Outlier in Beaver River.

3. *Basal Carboniferous Rocks of McAra's Brook.*

A description of these strata is given at page 89 P in connection with the Carboniferous section of the sea-shore at Merigomish.

4. *Basal Carboniferous Rocks of Salmon River Lakes and the West River of St. Mary's.*

That some doubt exists whether the rocks of this belt, in whole or in part, are not rather Millstone Grit, has been stated on page 7 P. No separation into groups has, however, been found possible; the strata are like those just described, except that finer beds predominate; and plants collected from them by Mr. Weston, on the Goshen Road, are, according to Sir J. W. Dawson, characteristic of the Lower Carboniferous (Horton series); so that, for the present, in the entire absence of stratigraphical evidence to the contrary, they will be so considered. The structure of the numerous obscure north-east and south-west anticlines which appear to cross this belt will be indicated on the map, as far as they can be made out in the few outcrops. These rocks lie, throughout the entire length of the belt, on the gold-bearing series (Lower Cambrian) on the south, and the Devonian on the north. The country occupied by them is for the most part low and barren, rocky or marshy, covered with innumerable shallow lakes from which long, sluggish, parallel streams flow a little east of south into Salmon and Country Harbour Rivers and into the East and West Rivers of St. Mary's, the last being not far from the southern boundary of the belt from Glenelg westward to its termination above Trafalgar. Possibly Millstone grit. Anticlines. Boundaries. Barrens.

In the river below the chapel at Salmon River Lakes, are gray coarse sandstone, grit and conglomerate, of loose texture and variable dip. Half-a-mile below, the dip is 237° $<$ 5°, the sandstone being false- Salmon River.

bedded, rusty-weathering, with pebbly patches. Similar rocks, still lower down, associated with reddish-gray fine sandstone, dip easterly at a low angle, although nearly vertical a short distance upstream A little lower, the dip of gray grit and conglomerate is 75° < 45°; still lower, 31° < 40°; and again, 80° < 50° near the contact of the Devonian rocks. To confound the latter with the Carboniferous here would be impossible, the Devonian being typical Grand River quartzites and slates. To define closely the boundary to the eastward is impracticable, but the Carboniferous sandstones do not come into the Ogden clearings, to the Cuilnamuc road, or probably further east than the head of the marshy lake below the post road. The boundary at Three-Cornered and Round Lakes is also uncertain, few outcrops being exposed; but is evident at Pringle Lake. The conglomerate in the road at the chapel is a gray, rusty-weathering, coarse, friable variety, succeeded above the lake by gray sandstone full of silvery mica, with a variable, often steep dip, probably indicating faults.

Contact with Devonian.

With the gold-bearing rocks.

Overlying the whin or quartzite of the gold-bearing series in the brook flowing from Hurley Lake, come gray fine sandstones and grits, like those seen on the Salmon River roads, interstratified lower down with rough, coarse conglomerate, composed of pebbles and large boulders of whin. In other branches of Country Harbour River, similar rocks are found. The road from the beautiful Eight-Island Lake, towards Lochaber shows for some distance bluish-gray soft argillite and gray and reddish-gray fine grit and sandstone, often very flinty, veined with quartz, and holding graphitized plants, perhaps Carboniferous. The sandstones of the rocky clearings west of McMillan Lake (page 60 P) are flinty, quartzose, veined with quartz and in part quartzites, associated with shaly and flaggy, argillaceous rocks, which are probably the doubtful rocks of the road. From Trout Brook, above the crossing of this road near Two-Mile Lake, Messrs. Weston and Robert made an important collection of fossils from similar sandstones and argillites. The latter are somewhat slaty, or jointed vertically at irregular, short intervals apart, so that pieces break out, two inches long, two wide, and three-quarters of an inch thick, and smaller. No true slate is found among them, but all are somewhat altered and have a flinty ring when struck; not far above the bridge, and extending a short distance above a ten-feet fall, beyond which the banks are low and the stream swampy, the more sandy beds contain a large quantity of mica, dipping upstream at a very low angle. The plants determined by Sir J. W. Dawson are *Lepidodendron corrugatum*, plentiful; *Stigmaria*, probably rootlets of the above species; *Cyclopteris* (*Aneimites*) *Acadica*, *Sphenopteris*, not determinable but like *S. artemisifolia*. Large numbers of *Cythere* were also detected in the shales.

Trout Brook.

Fossils.

Southward along the post road, these obscurely slaty rocks yield the blocks so largely used in building walls hereabout; they strike along the road for some distance past Fisher's mills, and dip at a very high angle toward the river. At the mill-dam, however, in the river and at the road, they turn at right angles and dip nearly vertically down stream, extending thence to the head of Two-Mile Lake. Round the foot of this lake, and for some distance along the west side, no rocks are in place, but the detritus is the same as that near Fisher's mills. In the brook near the head of the lake, reddish and greenish, tough argillaceous shales dip 137° < 18°, associated with flinty, whitish, rusty-weathering sandstone and grit, composed chiefly of quartz, with blocks of which the ground is covered. Around the shores of the little lake emptying into this brook, the land is also very rocky. **Sherbrooke road.**

In the first little branch of Boggs Brook (page 60 P), above the road, reddish-gray and gray flinty micaceous sandstone, grit and argillite dip 228° < 27°, resembling the rocks of Hugh McMillan's and Trout Brook and also those of the barrens in the neighborhood of St. Peter's. In the main brook, nearly opposite, similar strata, containing plants, dip 162° < 82°. Upstream, gray, greenish-gray and reddish, jointed, flaggy, micaceous argillite and fine sandstone dip 176° < 80°. Immediately below the mill is a flinty, pebbly grit, while at the dam, whitish, compact quartzite dips 178° < 85°. The outcrops on the road above the bridge are like those near Fisher's mills, but strike 180°. In the brook flowing from the south into this brook a little higher, bluish-gray pearly slates, with obscure graphitized fragments of *Psilophyton* represent the Devonian rocks of South Lochaber. **Boggs Brook.** **Devonian rocks**

Rocks precisely like the above are found in the brooks between Country Harbour Cross Roads and Melrose, sometimes in nearly horizontal bedding, at other times with a steep dip; and also between Eight-Island Lake and the Upper Cross-Roads, St. Mary's, where the rusty soil, blocks of gray, fine, flaggy, rusty-weathering sandstone, and sluggish, swampy brooks bring to mind the Millstone Grit districts near Sydney. In the neighborhood of Holy Hill, this formation comprises gray, greenish-gray and rusty, coarse and fine, very micaceous sandstone and argillite, containing stems of plants; bluish, calcareous, micaceous shales and flags, and gray conglomerate, with pebbles of whin and flinty sandstone, the dip of which is variable, the strata being tilted and broken. **Country Harbour.** **Resemblance to Millstone Grit.**

In Big Meadows Brook, the first outcrop below the road between Lochaber and Newtown consists of whitish, rusty and greenish-gray, sometimes very fine and flinty, but also pebbly, sandstone, containing minute veins of a mixture of ankerite and specular iron. No other rocks are in place for a great distance downstream, when gray and **East River of St. Mary's.**

reddish sandstone and argillaceous shale, micaceous, broken by joints, not greatly altered, and with a large predominance of the shale, are succeeded by reddish-gray, fine, micaceous, flaggy, wavy sandstone and argillite, finely ripple-marked. Down the East River of St. Mary's, from the confluence to the Lochaber branch, no rocks appear; but upstream, gray, flaggy, false-bedded, jointed sandstone covers the surface with blocks, rendering much of it unfit for cultivation. Up the brook from the south, opposite Neil Gunn's, and in Greenfield, narrow ridges of gray coarse and fine sandstone run between the branches, the dip being surprisingly variable.

Dip variable.

On the east side of Mitchell Lake reddish and greenish, crumbling, argillaceous sandstone and shale skirt a small portion of the shore. At the mill in the brook below, greenish shale and sandstone dip $306° < 50°$, and thick-bedded, gray sandstone is also found in some of the branches flowing into the lake, associated with shales and flags. The various outcrops of gray, greenish-gray, shaly and massive quartzose sandstone and grit which occur throughout this district do not require special mention. In no place are the exposures sufficiently good to yield a continuous section.

The rocks of Whidden Brook are like those of Big Meadows Brook, Fisher's mills, and the brooks at the head of Two-Mile Lake.

West River of St. Mary's.

Nearly all the tributaries of the West River cut through rocks like the foregoing, but only a few of these need be specified. In Archibald's mill-brook and Glencross Brook are gray and reddish sandstone and coarse conglomerate; in Clark and Indianman Brooks, gray and whitish, rusty-weathering, flinty, shaly and flaggy sandstone and conglomerate, with reddish and greenish shaly bands.

Ironstone. Coal.

In Donald McDonald's Brook, below Hattie's bridge, gray fine and coarse sandstone and slate full of broken plants, contain many layers of light-gray, rusty-weathering clay-ironstone, one inch thick and less, streaks of coal and dark shales, with films of calcspar. They extend up to the contact with the Devonian slates and quarzites. In Sutherland's Brook, are similar alternations, mostly of coarser beds. Hattie's Brook and Lake show gray, coarse, coherent sandstone, reddish-gray, compact, altered sandstone, dark greenish-gray ferruginous argillite, reddish and bluish-gray argillite, succeeded, upstream, by slate and quartzite, with minute quartz-veins. These rocks, for the most part coarse, are found at intervals on all the roads and in the river and brooks. In the Big Barren Brook, for some distance above the river, good outcrops of coarse sandstone and conglomerate are followed by finer sandstone and shale, full of *Lepidodendron* and *Cordaites*, and again by coarse grit. The pebbles of the conglomerate are derived principally from the gold-bearing series. Near Bryden Brook, on the

Fossil plants. Conglomerate.

track from Sunnybrae (page 63 P), a gray, coarse, friable conglomerate, contains pebbles, as large as cocoanuts, of rocks seen higher in the brook and described as Devonian.

The conglomerate is probably only in patches in the sandstones and shales of the river at Archibald Cameron's, which consist largely of dark argillaceous shale, sometimes very coaly, greatly jointed and coherent, but without quartz-veins. Higher up the river, below a dam and not far from Trafalgar, are fine outcrops of gray coarse grit and conglomerate, largely composed of pebbles of the underlying granite and gneissic rock, and succeeded upstream by reddish-gray fine and coarse pebbly sandstone in rocky ledges. In the vicinity of Ellen Brown's Lake, this sandstone is again met with, not far from the contact of Devonian quartzites and slates. Coaly shales.

G 1. Carboniferous Limestone.

A perfectly well defined base for this formation is given by the Blue Cape limestone, the outcrops of which, to the westward, at North Canso, Pirate Harbour, Lennox Ferry, St. Peter's, the Bras d'Or Lake, and other places have been already described.* It is overlain, at no great distance, by an important belt of gypsum, and rests unconformably upon all the formations from the Pre-Cambrian to the Carboniferous conglomerate. The contact of this limestone with the Devonian rocks of Guysborough Harbour has been already referred to.† At another point, at the mouth of Ingersoll Creek, the limestone is gray and reddish-gray, impure and concretionary, often shaly, contains hæmatite, and is mixed with conglomerate. Limestone and gypsum.

Another patch of limestone, not indicated on sheet 24,‡ is found on the shore road, at the north end of the bridge over Steep Creek, underlain by greenish, flinty, quartz-veined sandstone and conglomerate, by a considerable thickness of brown, red and green, mottled, splintery shales, and by black, friable argillite or slate, with brown, calcareous concretions, becoming more flaggy and sandy at the base. Steep Creek.

The limestone on the shore at North Canso, is apparently overlain by indefinite outcrops of greenish crumbly argillite and papery shale, with a band of red and green mottled shale; although the dip is so irregular that the exact relation of the different beds is obscure, the first rocks to the westward dipping $275° < 33°$, the limestone, after a concealed interval, dipping $325° < 19°$ to $340° < 25°$, and the underlying greenish flinty quartzite, in which it fills a depression as on the opposite side of the Strait, $0° < 19°$. North Canso.

* Page 50 P of this Report; Acadian Geology, p. 350; Geol. Survey Report for 1879-80, p. 56 F, 61 F, etc.

† Geol. Survey Report for 1879-80, p. 59 F.

‡ Geol. Survey Report for 18 2-83-84.

Blue Cape limestone traceable unbroken for 87 miles.

From the outcrops at Cape Pond and Blue Cape, the limestone passes under the sea to Barrio Head, running thence unbrokenly to the head of the Ohio settlement, about thirty-one miles, thence by St. Joseph, James River and Antigonish to Morristown, twenty-six miles further; it reappears on the shore at Knoydart* and runs about eight miles to Avondale, where it is overlapped by Millstone Grit as far as the margin of the Pictou coalfield. In the Antigonish basin it is frequently repeated by north-east folds, which will be readily understood from the map, some of which bring up Pre-Carboniferous strata. Outlying patches occur also at the College, at Hallowell Grant and Doctor's Brook, and a narrow belt extends up the East River of Pictou from Springville to Sunnybrae.

Folds.

Outliers.

Tracadie limestone quarry.

Antigonish Basin.—At T. W. Kinney's, southwest of Tracadie Harbour, several hundred tons of limestone have been quarried and burnt. The lime makes an excellent mortar with two-thirds sand, and has also been used with good effect on wheat- and grass-land. The limestone is bluish-gray, shaly and thick-bedded, oolitic and veined with calcspar. About Giroir's and Black Bridge, at the head of Tracadie Harbour, are several outcrops of reddish and green fine coherent sandstone, gray dirty limestone and purplish-weathering soft sandstone. On the shore at Barrio Head, are beds of greenish calcareous shale with nodules of more or less impure limestone; gray smooth calcareo-bituminous shales holding obscure shells; red and green, mottled argillite, jointed and ripple-marked; and reddish and gray sandstone, wavy and false-bedded, too shaly for building, containing streaks of coal and *Calamites*. Beneath one band of this sandstone is a layer of dark argillaceous shale with rootlets, streaks of coal and pyrites, which has been mined for coal, and is again underlain by shales, which occupy the shore for some distance east, becoming in places dark and slightly bituminous, and interstratified with thin layers of red shaly sandstone and nodular masses of impure limestone. These rocks extend to the mouth of Little Tracadie Harbour.†

Shells and plants.

Coal.

In the Monastery Brook, above the shore road, are high cliffs of reddish-gray, greenish and dark-gray shale, sandstone and marl, containing calcspar in minute veins in the bedding, in nodules, in vugs and in sheets in the joints. Near the monastery, these shales are associated with gypsum, underlain by twenty or thirty feet of gray bituminous limestone, in layers from four feet to nine inches thick, with fluorspar in calcspar veins. In the adjoining fields, gypsum is in place in mounds, white and without crystals, or saccharoidal and full of crystals of anhydrite. On the road to Tracadie wharf, broken land

Gypsum.

* Gesner's Geology, p. 134.

† Geol. Survey Report for 1879-80, p. 61 F.

perhaps indicates also the occurrence of gypsum or limestone among the soft rocks, but no outcrops are met with.

On Alexis Head, banks of gravel and boulders are succeeded by cliffs of red, gray and greenish smooth shales, mottled and in alternate layers, with bands of fine sandstone, often beautifully ripple-marked, but having the ripples interrupted by small pits, which give them a rhombic appearance. The marls and shaly and false-bedded sandstone at the west branch of Tracadie Harbour, contain broken plants. The few outcrops between Tracadie and Bayfield, consist of red sandstone and shale, with green and gray bands, containing comminuted carbonized plants; but better exposures are cut in the brooks, where the sandstones are sometimes quarried for rough building-stone. **Alexis Head, Tracadie.** **Fossil plants.** **Bayfield.**

Afton River, below the railway, exposes high banks of greenish-gray and red marl and sandstone, often like Millstone Grit. Above the Indian Reserves, reddish, greenish and gray smooth shales, like those of Black River, are associated in both branches with red coarse conglomerate, and overlie Devonian quartzites; while downstream are bands of ferruginous limestone and ripple-marked sandstone. At Gorman's corner, the basal limestone, wrinkled and oolitic, is in contact with flinty rocks. **Afton River.** **Devonian and Carboniferous.**

On the west point of Pomquet Island nearest the breakwater, gray, greenish-gray and reddish, fine, micaceous sandstone dips 334° < 45°. Further north, greenish and gray arenaceous shale and sandstone show impressions of fossil plants. On the shore, westward from Bayfield wharf, the first rocks seen are gray fine sandstone and arenaceous shale, rusty in spots and blackened with carbonized plants, with reddish-gray layers and lenticular patches of gray pea-conglomerate and coarse grit. But the greater part of the shore shows only wide beaches of fine gray sand, blown and rippled, strewn with boulders. Pomquet Harbour is low on the east side, from Heatherton northward nearly to the Indian chapel, where fine, gray sandstone, rusty-weathering, and not unlike that of Port Hood, dips about 300° < 50°. **Pomquet Island** **Fossils.** **Pomquet Harbour.**

Between Fraser's Grant and the post-road to Guysborough, the Lower Carboniferous country towards Heatherton presents many good outcrops of sandstone, shale, limestone and gypsum in the brooks; these rocks are always soft and marly, and are very different from the adjacent Devonian strata. **Gypsum.**

Among the red, green and gray soft Carboniferous shale, sandstone and rusty-weathering limestone overlying the Devonian red argillites in the various branches of Black River, none present any points of interest except the limestone and a band of gray and brownish sandstone quarried at Heatherton. The coal and underclay found near the mouth of Pomquet Harbour will be described hereafter. On the road **Black River.** **Sandstone quarry at Heatherton.** **Coal.**

from Bayfield to Heatherton the land is good, but somewhat clayey, showing occasional outcrops of reddish-gray sandstone; west of Pomquet Forks it is flat and uninteresting, with few rocks. Up Pomquet River, above the bridge at the telegraph road, ledges and cliffs of gray and reddish-gray fine soft argillaceous sandstones and flags, with green layers, rippled and wavy, are associated with red marl, and contain the "copper mine,"* worked some years ago, in a greenish-gray, nearly compact sandstone or underclay, full of plants, chiefly *Calamites* and *Cordaites*, partly converted into coal in thin layers or films, but partly, also, into gray sulphide and green carbonate of copper. Gray and red marl and sandstone, greenish and bluish-gray argillaceous shale and gray, strongly coherent shale or impure limestone, are found higher up, followed by cliffs of dark gypsum, speckled with white gypseous marl and impure limestone, red and grayish-white, crumbly, marly sandstone, cream-colored gypsum and dark, soft, earthy, strongly bituminous limestone, full of encrinites and broken shells. The beds are greatly contorted. The gypsum is shaly and conformable with the limestone, veins of selenite passing from one into the other; but, in some masses, gypsum and limestone are mixed, as if the former had been intersected, when plastic, by gypsum veins. Gypsum, gypseous marl and limestone occupy a considerable breadth in the river. At Meadow Green bridge, the lowest, or Blue Cape limestone, red crumbly shale and sandstone are well exposed and underlain higher up by red flinty Devonian rocks, the contact of which is also well seen in some of the streams near Marydale. In one of these, the limestone is bluish-gray, veined with calcspar, probably exceeds ten feet in thickness, and is interstratified with a band four or five feet thick, mixed with the red argillites. It will thus be seen that, in general character, these rocks are precisely like those assigned to this formation in previous reports on New Brunswick and Nova Scotia.

Pomquet copper mine.

Gypsum and limestone.

Fossils.

Meadow Green.

Outcrops of red sandstone and shale or marl, gypsum and limestone, in the neighborhood of St. Andrews, South River, Glenroy, and other places, require no special mention. A reported discovery of coal among these strata in a brook on the west side of South River, at John Fraser's, above the iron bridge at the head of the tide, proved, on examination, to be a bed of gray sandstone, full of large carbonized trunks of *Lepidodendron* and *Calamites*, mineralized throughout by coal and pyrites in layers.

Coal of South River of Antigonish.

A short distance out on the road from St. Andrew's to Vernal, fine, red soft sandstone and shale or marl, limestone and gypsum, are succeeded by flinty Devonian argillite and quartzite.

Contact with Devonian.

* Trans. N.S. Inst. Nat. Sc., Vol. IV., p. 75, and Vol. VI., p. 322.

The cliffs of the shore at Monk Head* show large exposures of gypsum, limestone, red marl and gray, fine, rust-spotted sandstone, with large patches of nut- and egg-conglomerate. The sandstone has been quarried for building, and was used in the abutments of the iron bridge at South River. Monk Head. Quarry.

These rocks, particularly gypsum,* are also found on Antigonish Harbour, below this bridge, as far as the mouth. An outcrop of limestone, near Taylor's road, is gray, massive, and spotted with galena. Antigonish Harbour. Galena.

Carboniferous limestone strata occur, with doubtful, variable dip, in South River, and its branches below Fraser's mills, as well as in the fields and roads about Pineville, Ashdale, and Dunmore. Along the brook on the west bank of South River, north of Fraser's mills, broken land seems to indicate the passage of the lowest limestone; and on the hill, not far to the northward, reddish-gray fine sandstone, said to be easy to work and to harden on exposure, has been quarried. North of Gillis Lake are outcrops of red and green marl, and limestone skirts the neighboring millpond on Dunmore Brook. Between Pitcher's farm and West River, red sandstone, marl and greenish-gray sandstone probably overlie the limestone. Quarry.

Reference has already been made (page 17 P) to the fossiliferous limestone which caps the syenite on Williams Point and the east side of Antigonish Harbour. This limestone is gray, massive and vesicular, resembling that of the Ohio River as well as in its relations to the immense outcrops of gypsum in the neighborhood and to the red shales and marls. The broken land about the harbour well exemplifies the term "plaster land." Limestone and gypsum.

On Right's River, near the head of Antigonish Harbour,† the limestone contains *Productus semireticulatus*, *P. cora*, *Cardinia Antigonensis* and other shells. Shells.

In the Beech Hill brooks, the frequent exposures consist of limestone and gypsum, overlain by red sandstone and marl, with dark bluish-gray papery shale, dipping usually at a low angle. Fine outcrops of Carboniferous limestone extend up the West River of Antigonish to the head of the settlement. On the road between Ashdale and West River, a bluish-gray bituminous limestone, full of shells and concretionary nodules, in layers four to six inches thick, with veins and films of calcite, is associated with reddish-gray argillaceous shale and fine sandstone. Beech Hill. Dark shales. Fossils.

On the road between Fraser's mills and Glen Alpine, greenish fine diorite and rusty amygdaloid have greatly altered the compact bluish-gray limestone of Blue Cape in its course from South River Volcanic rocks.

* Trans. N.S, Inst., Nat. Sc., Vol. IV., p. 72.
† Acadian Geology, pp. 304 and 347. Trans. N. S. Inst. Nat. Sc., Vol. IV., pp. 73 and 75.

past the head of Lochaber to Ohio. In the brook from the eastward, north of Glen Alpine post-office, the limestone is immediately underlain by red slates and sandstones of the Upper Devonian. In the brook from McMillan Lake, both above and below the mill, are red shaly sandstone and argillite, very flinty, jointed and perhaps Devonian. North and west of the mill are ledges of flinty quartz-veined sandstone; and in a brook not far south of the road, soft bluish-gray Carboniferous limestone. To the south-westward, in McGillivray Brook, Silurian rocks are overlain by Carboniferous conglomerate and limestone. One of the Ohio "limestones is of palæontological interest as containing trilobites, (*Phillipsia*)," *Spirifera*, *Productus spinosus* and other fossils.*

Devonian and Silurian rocks.

Trilobites.

An abrupt change from Cambro-Silurian metamorphic slates to Carboniferous strata is seen in Hartshorn Brook, a tributary of Beaver River, the latter consisting of bright indian-red marl, with green spots, very crumbly and little more than hardened mud, associated with masses of white and gray gypsum and limestone.

Contact with Cambro-Silurian.

The limestone of Brierly Brook and other streams near the railway, toward James River, is from six to ten feet thick, in layers two to four feet, bluish or dark-gray, flaggy, veined and blotched with calcspar, fit for building, and everywhere quarried. It is underlain both here and in the Ohio valley by greenish nut- and egg-conglomerate, invariably stained with copper ore near the contact, and worked for copper at many points shown on the map. From McIntosh's quarry† in a brook half a mile east of Brierly Brook, the limestone used in the Antigonish cathedral was extracted. Both here and to the eastward of Murphy's mills (Trotter's factory)‡ the limestone and overlying gypsum can be readily followed in great cliffs, mounds and pits, and in almost continuous exposures of the underlying conglomerate. No special description is required of the outcrops in North River and other streams flowing into Antigonish Harbour. Those of Ogden Pond have been figured and described by Sir J. W. Dawson § and Dr. Honeyman.||

Limestone quarries.

Copper ore.

Gypsum.

Ogden Pond.

On the shore at McIsaac Point, near Morristown, gray flaggy and shaly limestone, about seven feet thick, veined with calcspar and pink and white heavy-spar, rests upon highly inclined reddish and greenish grit or conglomerate, and is overlain by a much greater thickness of brecciated limestone. South of Ballantine Cove, conglomerate, containing a small quantity of green carbonate of copper, is unconform-

Barite.

Copper ore.

* Trans. N. S. Inst. Nat. Sc., Vol. IV., p. 74, and Vol. I., p. 114. Also Acadian Geology, p. 347.
† Trans. N. S. Inst. Nat. Sc., Vol. IV., p. 73.
‡ Trans. N. S. Inst. Nat. Sc., Vol. IV., p. 73.
§ Acadian Geology, p. 347.
|| Trans. N. S. Inst. Nat. Sc., Vol. IV., p. 72, and Vol. VI., p. 313.

ably overlain by light-gray, shaly, concretionary limestone, perhaps five feet thick; succeeded by cream-colored, massive, vesicular limestone passing upward into a brecciated, more or less concretionary, impure variety, containing only a few very indistinct fossils.

Outlier west of Lochaber.—The limestone near Dan. Gillis' house, in the College grant, is of the wrinkled Blue Cape variety, veined with calcspar, and may indicate a synclinal of the lower Carboniferous among the Devonian rocks of these hills. In the immediate neighborhood are outcrops of red argillite and trap. Limestone is also found on the road, in the fields behind the schoolhouse, and near the copper mine, where a little brook runs into a cave.

Outlier at Hallowell Grant.—The limestone seen at the Big Marsh post-office and mineral spring, and again about a mile further south, comprises shaly, brecciated and impure concretionary varieties, strikingly like those of the shore, at least ten feet thick, bounded on all sides and underlain by the gray, rusty-weathering, plant-bearing, micaceous conglomerate, sandstone and gray and black shales, from which a little coal was dug in the vicinity.

Mineral spring.

Coal of the underlying rocks.

Outlier of Doctor's Brook.—This outcrop of gray, compact, Carboniferous limestone, which was first described by Dr. Honeyman,* seems to be less than a quarter of a mile long and seven chains wide; it overlies Upper Clinton slates in the east branch of Doctor's Brook at Arisaig, half a mile above the fork, is eight feet or more in thickness, and has been burnt for lime.

Merigomish Basin.—A section of the strata, as they appear on the shore west of McAra's Brook, will be given with the Millstone Grit. It has been already stated (page 68 P) that Devonian red slates are overlain in Knoydart Brook by coarse conglomerate, false-bedded, with bands of greenish and gray flaggy sandstone, full of rusty carbonized plants. Immediately above the bridge at the mill, these rocks are overlain by bluish-gray compact limestone, succeeded, in the rocky rapids lower down, by gray, sandy flags and false-bedded sandstones, reddish shale and sandstone with concretionary layers. Near the shore road a gray and greenish flaggy sandstone, at least eight feet thick, contains plants converted into coal and stained bright green with copper.†

Knoydart Brook.

Coal and copper

Limestone is seen in Bailey's Brook, at John McLean's and again in Carmichael Brook, below the old road. Broken land perhaps marks

* Journal Geol. Soc., 1864, p. 339. Trans. N. S. Inst. Nat. Sc., Vol. I., p. 116; Vol. III., p. 15; and Vol. IV., p. 53.

† Trans. N. S. Inst. Nat. Sc., Vol. V., p. 198.

its extension down this brook, and on the railway west of Avondale, beyond which it is apparently overlapped by Millstone Grit.

Basin of the East River of Pictou.—The limestone of this basin with its accompanying fossils, has been fully described by Sir J. W. Dawson,* and Dr. Honeyman†; but the relations of this and the accompanying strata to the Cambro-Silurian, Silurian and Devonian rocks of the upper part of the river, and to the Millstone Grit of the Pictou coal-field have not yet been clearly defined. The limestone is like that of Morristown and Brierly Brook, has been largely quarried and is

Quarries.

overlain by gypsum, and by red and greenish sandstone and shale. The extent and relations of these rocks, so far as known, will be seen on the map.

G 2. Millstone Grit.

The possibility that certain small areas of the upper rocks in the Antigonish basin, about Tracadie and Bayfield, may be Millstone Grit, has already been stated, and also that those of the St. Mary's River basin may be partly or wholly of the same age; but the only area in which this formation clearly overlies the Carboniferous limestone and gypsiferous series, extends along Merigomish Harbour, from Lismore and Avondale south-westerly to the Pictou coal-field, being well exposed on the shore, in Bailey's Brook and in Barney's, French and Sutherland's Rivers. The following section of these and the Lower Carboniferous rocks on the shore, will serve to indicate their composition and general character.

SECTION OF CARBONIFEROUS ROCKS FROM PONDS, MERIGOMISH, TO KNOYDART, ON THE SEA SHORE, IN DESCENDING ORDER.

The Ponds.

G 2. Millstone Grit.	Feet.
1. Measures concealed, for thirty chains north-east from the mouth of the brook due north from Ponds post-office; dip 306° < 10° In the lower part, obscure reefs and broken banks of gray and reddish-gray fine, crumbling sandstone	115
2. Greenish-gray and rusty, flaggy and false-bedded sandstone	14
3. Reddish, fine, shaly sandstone underlain by gray and rusty false-bedded sandstone	5
4. Red and green, soft argillaceous shale with bands of reddish false-bedded sandstone with green and gray spots, underlain by gray, massive, very crumbly sandstone,	

* Acadian Geology, p. 285, etc.
† Trans. N. S. Inst. Nat. Sc., Vol. V., p. 213, etc.

	FEET.	
containing broken carbonized plants, and coherent concretionary masses. This gray sandstone is not unlike that of Port Hood and Margaree Island (Geol. Survey Report for 1882-84, pp. 53 and 76 H)............	10	
5. Measures concealed at the mouths of two little brooks; but seen on the reefs below high-water to consist of strata similar to the above, the lower beds of which are well exposed..	24	
6. Gray fine sandstone including a lenticular layer two inches thick of greenish-gray, calcareous conglomeratic rock, which increases further east to one foot, and is wholly concretionary, while still further east it is an underclay, showing fine *Stigmaria* converted into a mixture of coal, calcite, pyrite, blende and galena. Prostrate trees also occur in the sandstone, having the bark converted into coal, and in the bank hereabout, coal is said to have been sought. An undulation here turns the dip to 291°—300° < 15°, but it is only local although obscuring somewhat the thickness.—Mouth of a small brook..	26	*Stigmaria.* Coal.
7. Reddish and gray and greenish shale and sandstone, with a band of gray and rusty, flaggy and false-bedded crumbly sandstone, the gray beds full of broken, carbonized plants..............................	36	Fossil plants.
8. Measures concealed..................................	13	
9. Red, greenish and gray sandstone underlain by red marl, with bands of red sandstone, like the rocks of Lower French River. At the mouth of Bailey's Brook......	49	Bailey's Brook.
10. Measures concealed, but apparently red marl and sandstone seen in broken reefs at low water. Dip 304° < 10°, the shore being nearly on the strike for half-a-mile..	20	
11. Red sandstone and marl seen on broken reefs with large gaps. The sandstone is often knobby, with small calcareous concretions, and blotched with green, but as a rule, the rocks are very crumbly and micaceous. Several thick bands of gray sandstone. Dip 302° < 15°. A headland east of two little brooks.................	120	
12. The same as 11....................................	206	
13. Reddish, fine sandstone, in nearly continuous reefs. Dip 306° < 20°. Mouth of a small brook................	99	
14. Measures concealed, but probably the same as 13.......	16	
15. Reddish and gray sandstone, with a larger proportion of gray crumbly sandstone. Patches of conglomerate in the lower part, some of the pebbles being as large as a hen's egg..	115	
16. Measures not well seen at the mouth of Knoydart Brook.	92	Knoydart Brook.
17. Gray sandstone, more coherent than usual, containing large, spherical, concretionary masses of fine sand-		

Grindstones.	stone, often with a botryoidal surface. Certain beds are perhaps fit for grindstone, but generally they are shaly and false-bedded. The sandstone has at its base a greenish conglomerate, in part concretionary. The thickness of the strata is here doubtful, the dip changing by a fold or unconformity to 279° < 30°....	FEET. 22
	Total thickness..............................	982

G 1. CARBONIFEROUS LIMESTONE.

	18. Measures concealed..............................	103
	19. Gray sandstone, of indefinite thickness, included in 18..	..
Copper ore.	20. Reddish shales and sandstones, often finely ripple-marked, containing near the base a greenish concretionary rock, full of plants which are partly carbonized, partly converted into a gray ore of copper; in some places a nearly pure concretionary limestone, and apparently an underclay like 6..........................	445
	21. Red marl, with layers of reddish and greenish sandstones. To the mouth of a small brook. Dip 276° < 25°	50
	22. Red marl, with layers of reddish and greenish sandstone. The outcrops are no longer on the reefs, but in a high, rocky bank..............................	10
	23. Red rocks, chiefly crumbling sandstone, with one or two unimportant layers of greenish-gray sandstone......	417
	24. Measures concealed in a broad fishing-cove	370
	25. Red marl, with bands of reddish, greenish and gray fine sandstone. Dip. 284° < 20°	133
	26. Reddish, greenish and gray, fine sandstone, the gray full of carbonized plants and rusty spots, the red greatly predominating..............................	79
	27. Red marl, with bands of reddish and greenish, ripple-marked sandstone and shale..............................	148
	28. Reddish marl and sandstone, with gray and greenish layers..............................	259
	29. Gray sandstone, passing at top into red. Dip 276° < 30°.	10
	30. Red marl, with thin coherent layers of light-colored, impure limestone..............................	3
Limestone. Barite.	31. Gray, reddish and light-greenish limestone, for the most part compact; finely oolitic at top; blotched and veined with calcite and containing little cubes of galena, cubes and crystalline aggregations of pyrites, but no fluor-spar was seen as in similar limestones elsewhere, although heavy spar is largely mixed with the calcite. Thickness, 15–20 feet..............................	17½
	32. Gray, soft, laminated limestone or marl................	5
	33. Reddish sandstone..............................	6
	34. Limestone, like 31..............................	10
	35. Gray laminated limestone or marl..............................	3½

	FEET.	
36. Red sandstone and marl. The continuity of the measures is broken, and it is possible that 31–35 are here repeated,	21	
37. Limestone like 31	20	
Total thickness		2110

G 1m. CARBONIFEROUS CONGLOMERATE.

38. Reddish sandstone, shale and marl, with gray and greenish bands, forming high, rocky cliffs. Dip as above	580	
39. Dark greenish and reddish white-spotted amygdaloid, veined with white and reddish calcite. Some of the amygdules are as large as cocoanuts, usually of calcspar, but also of zeolitic minerals, chalcedony, chlorite, etc. The texture of the trap is variable, and it passes into greenstone or diorite. The alteration of the adjoining beds is not noticeable	10	
40. Reddish rough conglomerate and grit, holding pebbles of a gray oolitic limestone, like 31, but otherwise all clearly derived from the Silurian and other Pre-Carboniferous strata, sometimes as large as a cocoanut, but usually much smaller	10	
41. Greenish, concretionary, nodular, impure limestone, underlain by a mass of amygdaloid	2	
42. Conglomerate, friable and reddish, like 40, cut by irregular masses of trap which does not follow the bedding as closely as before, but often cuts across it, seldom, however, altering the conglomerate more than three or four inches from the contact. At the mouth of McAra's Brook, the conglomerate and trap are greatly confused, the former apparently holding blocks of the trap. Thickness necessarily indefinite. Dip 291° < 30°	543	
		1145
Total thickness of Carboniferous rocks		4237

Amygdaloid.

McAra's Brook.

A large portion of the two upper groups of this section is repeated in Bailey's Brook, as follows:—

SECTION OF CARBONIFEROUS ROCKS IN BAILEY'S BROOK,

IN DESCENDING ORDER.

G 2. MILLSTONE GRIT.

	FEET.
1. Measures concealed at mouth of the brook and below 9 of section on the shore. Dip 303° < 15°	308
2. Greenish and gray flaggy sandstone, thickness undefined	..
3. Measures concealed	149
4. Reddish-gray sandstone, overlain and underlain by red marl	6

		FEET.	
	5. Measures concealed to the bridge at the main post road	41	
	6. Gray and reddish-gray shaly and flaggy sandstone.......	15	
	7. Measures concealed, but reefs of reddish and gray sandstone occasionally seen..........................	160	
	8. Gray flaggy sandstone. Dip 303° < 10°................	10	
	9. Reddish-gray, fine, flaggy sandstone, and smoothly-bedded, argillaceous shale; seen only at intervals in the brook. Dip 303° < 12°..........................	130	
	10. Reddish, fine, ripple-marked sandstone and argillaceous shale, well-exposed in reefs and banks. Bridge on a good road. Dip 289° < 10°..........................	26	
	11. Red rocks, chiefly soft crumbling marl, with bands of reddish and greenish-gray sandstone and shale, cut through and exposed by the brook, both immediately above the road and again a mile higher upstream ...	28	
	12. Gray shaly and flaggy sandstone	12	
	13. Red rocks, like 11. Dip 296° < 7°...............	50	
Fossil plants.	14. Gray rusty-weathering sandstone, full of carbonized plants, and mixed with small patches of concretionary conglomerate. Probably No. 17 of the section on the shore and also the sandstone seen at a foot-bridge, about fifty chains below the bridge near D. D. McDonald's shop, on the road between Knoydart and Avondale....................................	7	
	Total thickness of Millstone Grit		942

G 1. CARBONIFEROUS LIMESTONE.

	15. Reddish sandstone and marl, with greenish and gray bands, not continuonsly exposed in Bailey's Brook, but better seen in Vamey's Brook. As the distance across the strike between 14 and 16, both here and in Vamey's Brook, is not more than a mile, the thickness is probably, with the prevailing low dip, less than 800 feet, indicating a considerable unconformable overlap—for there is almost certainly no fault....	800	
Limestone and copper ore.	16. Bluish-gray compact limestone; veined with calcspar, often ferruginous, and containing in one place specks of copper pyrites. In Bailey's Brook there appear to be two or more bands resting immediately on red Devonian slates, as also in Vamey's Brook; while at John McLean's, it overlies rocks, supposed by Dr. Honeyman, to be Cambro-Silurian. It is seen again in Carmichael's Brook, and again doubtfully indicated by broken land on the west side of Barney's River, near Avondale railway station, where it is apparently overlapped by the Millstone Grit....................	..	
			800
	Total thickness of Carboniferous................		1742

In Barney's River, below the confluence of Gordon Brook, and in other brooks of the neighborhood, gray and greenish, brown and reddish sandstone and shale, the former sometimes quarried for building, and holding spheroidal concretions of harder, nodular sandstone and many carbonized plants, are exposed at intervals in the cliffs. Immediately above Gordon Brook are banks of gray, fine, flaggy and shaly sandstone, rusty and full of carbonized plants, which is in thick beds higher up, has been quarried, and is underlain by reddish ripple-marked argillaceous shale and crumbly false-bedded sandstone containing patches of conglomerate and concretionary limestone. Above Avondale bridge, the Carboniferous rocks are underlain by greenish flinty Medina sandstone; but at the bridge, and also in Anderson Brook, Carboniferous sandstone is in place. On the south shore of Merigomish Harbour, on all the roads in the neighborhood, in the brooks and on the railway, are frequent outcrops of these strata. Near the Presbyterian church, reddish-gray and greenish, soft, friable sandstone and arenaceous shale, with impressions of *Calamites* and other fossil plants, and concretionary masses one foot in diameter, have a north-westerly low dip.

Barney's River.

Sandstone quarries.

Fossil plants.

Contact with Medina.

Merigomish.

Near the mouth of French River, a fine grindstone grit has been largely quarried from a bed ten to fifteen feet thick, dipping $6° < 5°$; whereas, a short distance further east, the dip appears to be $111° < 7°$. Gray shaly sandstone, greenish argillaceous shale, reddish or brown, micaceous, bituminous sandstone and marl, with gray calcareous conglomerate and associated rocks, are found on the shore to the eastward. About two hundred yards east of Mitchell's wharf, a gray and reddish, flaggy and shaly limestone has been quarried and burnt, and shows on another point still further east.

Grindstones.

Limestone.

In Huggan Brook, are gray and reddish, rusty-weathering, crumbly, flaggy, shaly and false-bedded sandstones, containing plants, in which traces of coal have been discovered. Near Piedmont station and on the valley road, there are outcrops of conglomerate between these finer beds and the Cambro-Silurian strata of the hill; thence the conglomerate follows the boundary towards French River.

Conglomerate.

Fine exposures of Millstone Grit occur in picturesque nearly continuous cliffs along French River, between the shore road and Glenshee. The first beds seen above the salt marshes are of red and green soft marl and fine sandstone, followed upstream by gray fine sandstone, fifteen feet thick, which has been quarried, capped by ten feet of red marl and sandstone. Higher still are reddish-gray, fine, flaggy sandstones, certain layers of which are mottled gray and dark-reddish, like those of Hawkesbury, others rusty and containing bands of dark nut-conglomerate, remarkably persistent as far as seen. Gray sandstone

French River.

Quarries.

Conglomerate.

is interbedded with red marl and flags, followed upstream by a wide belt of gray sandstone, then by a great thickness of red rocks, interrupted only by occasional bands of gray and greenish sandstone. Similar alternations of red strata extend for half a mile upstream; some of the beds include nodular concretions and bands of impure limestone and ironstone, and are blotched in places with calcspar, like the rocks of Afton and Pomquet Forks. The gray sandstones have the usual markings of carbonized plants. The dip is variable, and the measures are folded, an anticlinal axis apparently following the river for some distance.

Ironstone.

Beneath these red rocks is a band of red crumbly conglomerate, twenty-four feet thick, underlain by marl and by a gray conglomerate, enclosing a lenticular seam, three inches wide, of bright clean coal, seen for three feet in the river, but thinning out at both ends. Red conglomerate and marl follow. The former greatly predominates and contains pebbles, as large as cocoanuts, of red and green, mottled, fine, micaceous sandstone; reddish, impure limestone or marl, reddish-gray, fine, flinty sandstone, like that of Hawkesbury; reddish-gray, flinty, quartz-veined Devonian quartzite; whitish-gray fine sandstone, whitish quartzite veined with calcspar and ankerite, containing hæmatite; and a pebble of compact, earthy, red hæmatite as large as a hen's egg. The pebbles of mottled rock greatly predominate, and are almost certainly Lower Carboniferous, so that this conglomerate, which occupies a breadth of nearly half a mile in the river, belongs probably to the base of the Millstone Grit. It is seen to overlie metamorphic rocks, and can be traced in contact with them along the telegraph road to the westward of Glenshee.

Coal.

Pebbles of iron ore in conglomerate.

Junction of metamorphic rocks.

Sutherland's River.

In the railway cuttings about Merigomish and Sutherland's River, gray and reddish flaggy sandstones with concretionary layers have a northerly dip, these layers passing into limestone of fair quality. Below the railway, on the right bank of the river, are many blocks of gray sandstone and concretionary calcareous conglomerate, and at one point, a cliff of conglomerate or breccia eight feet thick, overlies gray flaggy sandstone. On the east side of the river, about two hundred yards above the railway bridge, the dip is 338° $<$ 47°. At the bridge, the angle of the dip is 26°. A short distance higher, a sandstone, that has been quarried, dips $<$ 16°, the red rocks above $<$ 55°. Above the bridge on the telegraph road, the rocks are greatly disturbed for some distance, consisting of red shale and sandstone with gray layers, holding carbonized plants, some bands being speckled reddish and green, like the sandstones of Hawkesbury. A section of these rocks, at Ross' bridge, is given by Sir William Logan.* At the

Fault.

Logan's section

* Geol. Survey Report for 1866-69, p. 12.

small brook from the westward, about a mile higher, they are succeeded by gray broken argillite and reddish, massive, fine, flinty sandstone, followed upstream by bright-red, calcareous, coarse conglomerate, mixed with sandstone and shale, with green streaks and blotches, and cut by dark calcareous trap. All the pebbles of this conglomerate appear to be Pre-Carboniferous, it extends to the contact of the metamorphic rocks in the falls at Park's mills. **Park's mills.**

The fine exposures of Millstone Grit in Pine Tree Brook and Gut have been described by Sir William Logan.* At the very head of the cove south of James Small's, conglomerate *débris* denotes the presence of the overlying Permian. **Contact with Permian.**

G 4. Permian.

Rocks of Newer Coal Formation, Upper Coal Formation, Upper Carboniferous, Permo-Carboniferous or Permian age are largely developed on the shore between Merigomish and Pictou Harbour, as described by Sir J. W. Dawson,† but from this series he has excluded, notwithstanding its strong general resemblance to these rocks, the New Glasgow conglomerate, which seems to be its proper and natural base, referring it instead to the "upper part of the Millstone Grit or lower part of the Middle Coal Formation," a classification followed by Sir William Logan,‡ probably on the authority of Sir J. W. Dawson, just as he places in his Devonian series in the Pictou coal-field, on the same authority,§ rocks belonging to several different periods of formation, because being outside the coal-field, they were only incidentally examined by him. Of the New Glasgow conglomerate, Sir J. W. Dawson wrote in 1845: "The coal measures of the Albion mines, on the banks of the East River of Pictou ...... are succeeded, in ascending order, by a great bed of coarse conglomerate, which, as it marks a violent interruption of the processes which had accumulated the great beds of coal, shale and ironstone beneath, and as it is succeeded by rocks of a character very different from that of these older coal measures, forms a well-marked boundary, which we may consider as the commencement of the Newer Coal Formation."|| That the great break is also accompanied by unconformity is conclusively shown by Logan and Hartley**; and also that the line of separation between the conglom-

New Glasgow conglomerate.

Sir William Logan's and Sir J. W. Dawson's views concerning it.

Unconformity.

* Geol. Survey Report for 1866-69, p. 9.

† Acadian Geology, p. 320.

‡ Geol. Survey Report for 1866-69, pp. 13 and 65.

§ Geol. Survey Report for 1866-69, p. 7; Acadian Geology, pp. 319 and 502; Trans. N. S. Inst. Nat. Sc., Vol. III., p. 105; Canadian Naturalist, Vol. IX., 1881, p. 11; and the present report, p 33 P.

|| Quarterly Journal of the Geological Society of London, Vol. I., p. 322. Cf. also Trans. N. S. Inst. Nat. Sc., Vol. II., p. 95.

** Geol. Survey Report for 1866-69, p. 13, line 34, and p. 66; Suppl. Acad. Geol., p. 36.

Faults do not affect the conglomerate. erate and the coal measures is not a fault. On this assumption, there is no necessity for the explanation of the structure by the singular "Devonian thrust up" (page 65) and thinning of the conglomerate toward the dip, the faults affecting the coal measures having, perhaps, as at Springhill, been produced before the deposition of the conglomerate, which has subsequently overlapped the unconformable contact of the Millstone Grit and Pre-Carboniferous beds, another proof of which is found in the occurrence of a large patch of conglomerate resting upon McCulloch Brook. the latter in McCulloch Brook, at and above the crossing of the Acadia Company's railway, but not shown on Logan's map.

It seems highly probable that the above is the true explanation of the structure, notwithstanding all that has been subsequently written to disprove it,* a supposition also greatly strengthened by the tracing of the belt of conglomerate eastward from the last outcrops mentioned Permian of Big Island. by Logan, through Quarry and Olding Islands to Robinson or Big Island, where the rocks are admitted to be Permian. The same great physical break between the so-called Newer Carboniferous and older rocks is found in the Cumberland district, in parts of which there seems just as much reason to place the former in the Millstone Grit. The tracing of these strata eastward, to join those of Pictou Harbour, should make the unconformity still more evident and remove every The fossils Permian. doubt. The fossil plants obtained from the beds overlying the New Glasgow conglomerate have a Permian aspect,† and therefore the whole Quarry Island. series may for the present be regarded as Permian. Nearly opposite the southwest corner of Quarry Island, on the mainland, cliffs of conglomerate, with small, lenticular bands of red sandstone, dip $318° < 9°$. On the island, near this point, are good outcrops of reddish and greenish sandstone and arenaceous shale, underlain to the south-eastward by red marl, with thin bands of gray and reddish, striped, calcareous, concretionary sandstone, intermixed, in the cove to the eastward, with red pea- and nut-conglomerate. Three hundred yards from the east Grindstones. point of the cove is the quarry from which the island takes its name, still extensively worked for sandstone used in the manufacture of grindstones, which are dressed on the ground. The bench at present worked is fifteen feet thick, overlain by greenish argillite. On the north point, and skirting the shore from the head of the northwest cove to the low-water beach, where the island joins the mainland, is Limestone. the botryoidal limestone used by Logan to determine‡ the summit of the New Glasgow conglomerate, which seems here to have lost its conglomerate character, and to be made up largely of finer sediments. The calcareous band is underlain by reddish, soft, argillaceous, shaly

* Geol. Jour., 1853; Acadian Geology, pp. 321 and 343; Supplement, pp. 34, 36 and 49.
† Suppl. Acad. Geol., p. 33.
‡ Geol. Survey Report for 1866-69, p. 14.

marl like that of Savage Point (page 96 P). Reddish fine shale, flaggy sandstone and marl, probably of this age, extend along the north shore of Indian Island for one hundred and fifty yards from the western point. At the point are similar rocks, also like those of the west end of Quarry Island, with thin green bands. **Indian Island.**

For two hundred and fifty yards along the south shore are reddish sandstone and marl, with patches of green marl; succeeded at six hundred and ten yards from the point by reddish and greenish-gray fine sandstone, blackened with broken carbonized plants, and containing calcareous, concretionary patches; underlain by reddish, fine sandstone and pea- and nut-conglomerate, the pebbles being obscure but apparently derived from Lower Carboniferous rocks, and the surface of the sandstone covered with numerous scales of specular iron, also present, but in less abundance, in the conglomerate. On the eastern point of the easternmost of the two little islands north of Indian Island, are large blocks of gray, impure concretionary limestone, gray and reddish sandstone, with large, hard spherical concretions. At both the east and the west ends of the western island, are similar blocks, with a large proportion of red. But no rocks are in place. **Fossil plants.**

On the north-east point of Olding Island, red sandstone is seen at low water; further west, gray and greenish-gray sandstone and argillaceous shale; and at the western and south-eastern points, other outcrops of sandstone. On the north side, a quarry was opened some years ago. but has been worked out; here a band of gray, impure, concretionary limestone, containing masses of the botryoidal variety, probably, indicates the upper part of the New Glasgow conglomerate. **Olding Island.** **Quarry.** **Limestone.**

From the last exposures of Millstone Grit at the Ponds westward to the Big Island of Merigomish, the shore is low and sandy, with broken banks. The first rocks on the north-east side of the island, west of the long beach, are gray sandstone, with a slight inclination seaward, sometimes coarse and pebbly, but with layers fit for grindstones, in thick or thin beds, crumbly, false-bedded, rusty with carbonized plants and trees, and interstratified with thin layers of greenish argillaceous shale. Where they overlie a small coal seam, these sandstones become coarse, yellowish and pyritous. The coal is from twelve to eighteen inches thick, tolerably regular as far as seen, bright and clean, but with streaks of pyrites and mineral charcoal; it rests upon a soft fire-clay at least eighteen inches thick, underlain by yellowish grit, with efflorescent iron sulphate on the surface, succeeded a short distance south by red argillaceous shale of considerable thickness, interstratified with gray thick-bedded sandstone and grit, holding a prostrate tree, two feet in diameter, mineralized with white and black calcspar. Bluish and greenish-gray, fine, shaly and flaggy sandstone, with hard **Big Island of Merigomish.** **Grindstones.** **Fossil plants.** **Coal seam.** **Prostrate tree.**

spheroidal and botryoidal concretionary masses, coarse, gray, crumbly, sandstone, and a calcareous, fine concretionary conglomerate, two feet thick, underlie to Merigomish Point, beyond which, for some distance south, outcrops are more obscure and seen only at low water. The thickness from the coal to this conglomerate is probably about two hundred and sixty feet. North of the base of Savage Point there is exposed a set of soft, red marls and sandstones with thin, concretionary bands of limestone and sandstone, dipping at a much higher angle than the strata north of Merigomish Point. The inner shores show no sections, except at Smashem Head, where fine, gray sandstone and concretionary conglomerate or impure limestone are well exposed. In the cove west of Smashem Head a few blocks of concretionary, botryoidal limestone are found; these are more numerous on the outer shore of Glashen Point, and, as they are hardly likely to have been carried by ice, may indicate the passage of the Quarry Island calcareous band. On Glashen Point are seen, at low water, beds of gray and reddish, hard, shaly sandstone used for scythe-stones. At the south-east corner of Finlayson Island, one of the Pig Islands, are indefinite outcrops of gray fine sandstone with spherical concretions, fossil, plants and patches of gray, impure, concretionary limestone.

Smashem Head

Finlayson Island.

The rocks overlying the New Glasgow conglomerate, on the East River of Pictou, have been fully described by Mr. Henry Poole* and Sir J. W. Dawson.† On the east side of the river, these comprise reddish and gray sandstone full of plants, and greenish or bluish-gray and blackish carbonaceous shale. Immediately south of the mouth of Smelt Brook, and, again, further south, the sandstone has been quarried. Beds, similar to these, occur further north, all dipping at a low angle; while in the cove immediately south of Ship-yard Point, bright-red and green marl rise into a crumbling cliff. Greenish-gray, rusty-weathering sandstone, full of large specks of white mica, forms part of Ship-yard Point and many of the reefs as far as the Big Gut bridge, between which and the ferry wharf at Fisher's Grant occur only obscure outcrops of gray and reddish, friable, nearly horizontal sandstone and grit, containing *Calamites* and other plants, and hard concretionary masses of calcareous breccia or conglomerate passing into nearly pure limestone.

East River of Pictou.

Black shale.

Quarries.

Fisher's Grant.

Limestone.

Similar rocks extend to the mouth of Pictou Harbour and also inland, producing sandy, excellent soil.

On the west side of the East River, the first rocks seen, a considerable distance beyond the conglomerate, are dark shales and sandstones, apparently the extension of those of the east side. At the mouth of

* Trans. N. S. Inst. Nat. Sc., Vol. I., p. 36.
† Suppl. Acadian Geology, p. 35.

Middle River, in the cove south of Skinner Point, good exposures of reddish-gray and whitish fine sandstone and grit, cream-colored argillaceous shale and reddish, crumbly, arenaceous shale, dipping $74° < 14°$, indicate a turn of the basin to the northward, a corresponding flexure of the underlying conglomerate bringing the latter to the shore near the loading ground at Granton. On Begg's Gut, reddish and gray shale and sandstone are overlain, in a little brook from the eastward, by twenty feet of greenish-gray and gray, free-working sandstone, in thick beds, quarried to some extent by Mr. R. E. Chambers, of Truro. Little blasting is necessary, the stone being removed by wedging. A short distance above tidewater in Begg's Brook, red and gray, fine, crumbly grit prevails. Middle River of Pictou. Sandstone quarry.

For nearly three-quarters of a mile above the loading-ground, Middle River shows no rocks; then reddish, shaly sandstone caps conglomerate in a bank fifteen feet high, the pebbles of the latter ranging in size from a cocoanut downward. Further south on a flat point, clay is obtained for brick-making; and immediately beyond, red soft grit is associated with bright-green marl, rich in carbonized plants, underlain by coarse conglomerate, with bands of reddish-gray sandstone and shale. Other exposures of reddish marl and conglomerate are found as far as the narrows, as shown on Logan's map, and above tidewater form rough reefs and high, steep banks. On the road from Alma mills, westward across Greenhill, the conglomerate is well developed, but has not been closely examined. Brick-clay. Fossil plants. Greenhill.

At the base of the sandbeach on the east side of the mouth of Pictou Harbour, are outcrops of bluish-gray fine sandstone; while up the creek beyond, to the bridge on the shore road, are cliffs of gray and greenish-gray sandstone in nearly horizontal layers, sometimes false bedded, rusty and pebbly, with upright trees and carbonized plants, streaks and blotches of coaly matter, some of which have been dug but seldom exceed an inch in thickness. Above the bridge are broken banks of similar sandstone with a northerly inclination, which is somewhat obscure, not from lack of exposures, for the cliffs are twenty feet high and the reefs numerous, but owing to the coarse, irregular beds and low angle of dip. Some of the land in the neighborhood is very rocky. Ferrous sulphate oozes from the cliffs, and the water of many of the springs is strongly astringent. Search for coal. Mineral springs.

East and west of Mackenzie Head are repetitions of these rocks, with a north-westerly dip; at Roaring Bull Point the dip is north-easterly, and the cliffs show red marl and fine crumbly sandstone, some of the upper beds being very calcareous, concretionary nodular and capped by gray, crumbly, thick-bedded sandstone. Roaring Bull Point is rocky from base to "bill," fine gray sandstone with a tinge of red dipping Mackenzie Head. Roaring Bull Point.

eastward at an angle of 10°. There is little variety in the rocks to the eastward, which appear on all the headlands and in many of the coves; some parts contain more plants than others, or are coarser, or have hard concretionary masses which give rise to irregular weathering. Evans Point is very rocky and shows a band of bluish-gray, concretionary, calcareous conglomerate, underlying sandstone. The inner shores of Chance Harbour are low, and only a few outcrops of reddish and gray sandstone are found on those of Little Harbour. In the millbrook, below Stewart's mill, fine gray shaly sandstone prevails, as well as to the eastward and on the road up the millbrook. On the north side of the railway and Merigomish road at Glenfalloch a gray fine sandstone dips north-westward at a low angle, and has been largely quarried.

Fossil plants. Little Harbour. Quarry.

At the west end of Roy Island begin reefs of gray false-bedded sandstone, which extends in unbroken cliffs along the outer shore, shows little variety and has been quarried for grindstones at several points. Not far west of Colquhoun Point a prostrate tree, mineralized with white and dark coaly calcspar, shows concentric, agate-like layers from the pith outward, probably due to the mode of deposition of the calcspar. In the same beds are upright trees and roots mineralized in the same manner. The sandstone which contains many hard, concretionary masses is of finer sandstone, is traversed by long joints parallel to the strike and crossed at right angles by others which give rise to fissures in the soil of the bank above. The inner or eastern shore of Colquhoun Point is inaccessible below the cliffs even at low water. Sandstone was at one time quarried on King Head. The shore to the southward is for the most part occupied by soft red and green marl and sandstone, with greenish concretionary layers. In a little brook north of Quarry Island are slabs of whitish-gray impure limestone about three feet thick, probably from outcrops overlying the red sandstone of the brook. It is not the botryoidal limestone, but overlies it and apparently forms part of the belt of red rocks passing through Big Island.

Roy Island. Grindstones. Fossil trees. Limestone.

On the road from Quarry Island westward to the main road, reddish and gray fine sandstone and shale are underlain by coarse friable conglomerate, accompanied by huge blocks and outcrops of gray concretionary limestone, part of which is botryoidal, and has been burnt. The coal seam here is supposed by residents to be the same as that of Big Island, but perhaps underlies it, although this is still uncertain, pending the examination of the associated strata.

Limestone and coal.

Volcanic Rocks.

These rocks occur in the region of which this report treats, in large, important areas with others of sedimentary origin, and have frequently been adverted to. They belong to several distinct periods, but it

has been often found impossible to determine what these periods were, although in some cases this can be readily done. Viewed generally, however, they may be provisionally referred to the following groups:—

1. The old crystalline series, containing all the massive rocks, and perhaps also the schists described as Pre-Cambrian. 2. Igneous rocks which, like those of Georgeville, cut the lower Cambro-Silurian conglomerates. 3. Contemporaneous volcanic rocks of the Middle and Upper Cambro-Silurian, occupying one of the two largest tracts covered by these rocks. 4. Contemporaneous rocks of Lower Devonian age, found south of Guysborough River and McPhee's mill-brook. 5. Dykes cutting Silurian, Middle and Upper Devonian rocks. 6. Contemporaneous volcanic rocks and dykes traversing the Carboniferous conglomerate and lowest bed of limestone at St. Peter's and elsewhere. **Classification.**

1. *Pre-Cambrian Volcanic Rocks.*—These having been fully described at page 7 P of this report, need not again be referred to.

2. *Georgeville Intrusive Rocks.*—These rocks, at their contact with the Pre-Cambrian and Cambro-Silurian, are described at page 8 P. Further east, at a small island or rock near Georgeville, is a red and cream-colored syenite or quartz-felsite, containing very little hornblende, and in places a pure quartzite, very like the flinty rock of Frenchman's Barn, cut by dykes of greenish soft trap, and sending in every direction, into the adjoining flinty argillites, veins not exceeding two inches in thickness. It is also mixed with the argillite in masses; sometimes nearly compact, but also very coarse. On the shore road, the syenitic and dioritic rocks all pass into porphyritic felsite, but generally contain a large quantity of hornblende, and also mica, and become pure hornblende-rock or a mixture of hornblende and quartz.

They come to the shore between Georgeville and Malignant Cove, where they are mixed with crystalline limestone and other rocks already described, and with a rock composed of quartz, felspar and limestone, like that of Ingonish River,* the dip being greatly disturbed and large veins of quartz being on both sides of the contact. They are here also cut by three dykes of black trap, the largest fifteen feet wide, and by veins of red compact syenite or quartz-felsite, like that described above, which is thus perhaps newer.

The syenite of James River and North River is probably younger than the above.

3. *Other Cambro-Silurian Volcanic Rocks.*—Mention has been made of the agglomerates, amygdaloids and similar rocks associated with the sediments of Doctor's Brook, Barney's River, and other places; and of the masses of syenite and diorite which break through them at

* Geol. Survey Report for 1882-83-84, p 36 H.

many points, as in the Antigonish hills and James River; but some further particulars regarding the most interesting of this series may not be out of place. The syenite which forms so large a portion of the hilly country north of the railway at James River, where intersected by this river above the railway bridge, consists of a glistening bright-red variety, with little hornblende, traversed by dykes of dark-green fine diorite, and succeeded upstream by greenish-gray siliceous slates. In the first branch from the west, these rocks are also present, as well as in the streams to the eastward.

James River.

Brierly Brook.

In Brierly Brook, reddish or flesh-colored quartz-felsite, with porphyritic crystals of felspar and numerous veins of quartz, is associated with greenish and reddish massive diorite and felsite. In the extension of the Cambro-Silurian rocks westward, the volcanic portion at Barney's River and Marshy Hope need not again be adverted to.

The Arisaig Trunk road, immediately south of the Hollow, is occupied by chloritic, serpentinous and calcareous rocks, porphyritic felsite, mottled red and green amygdaloid, blackish, fine chloritic diorite, and greenish and gray, mottled, fine and coarse breccia or fragmental felsite, interstratified with Cambro-Silurian sandstone. On the old road past Donald McLellan's, greenish and mottled epidotic, soft, fragmental shale is mixed with porphyry, among Cambro-Silurian sediments; and in the branch of Doctor's Brook east of the Trunk road, with greenish, massive, fine, calcareous diorite, gray, soft slate or amygdaloid, containing spots of clear quartz and other minerals, and cutting irregularly across red argillite in patches or following in the bedding, in both cases partaking of the lamination of the sedimentary portion. On the road through the back settlement of Arisaig and between Doctor's and McNeil's Brooks, fragmental and trappean rocks abound; and near the confluence of the east and west branches of Doctor's Brook are mixed with diorite and syenite, porphyritic felsite, and felsitic slates of great variety of color, like those of Coxheath; while red syenite, associated with greenish coarse diorite, rises into the peak of McNeil's Mountain.*

Doctor's Brook.

McNeil's Mountain.

In Malignant Brook, flinty rocks are cut by dykes of diorite and amygdaloid. The coarse syenite and diorite to the eastward are older, and contain large porphyritic crystals of felspar. In the little branch west of Malignant Brook, near the shore, and in the neighboring fields and woods, are large outcrops of reddish or brown amygdaloid, red syenite, and dark, fine, porphyritic diorite.

Piedmont.

Among the slates and grits of the hill south of the Piedmont valley are bright-red coarse syenite and quartz-felsite, cut by irregular

* Trans. N. S. Inst. Nat. Science, Vol. IV., p. 50.

veins of quartz, and mixed with greenish-gray chloritic, calcareous diorite.

The volcanic rocks in the neighborhood of Eden Lake are perhaps partly of this age. Those of the upper part of the East River of Pictou have already been described. Eden Lake.

4. *Lower Devonian Volcanic Rocks of Guysborough.*—That some of the volcanic rocks in the Devonian belt stretching from Guysborough Harbour to South River Lake are contemporaneous, or nearly so, with the sedimentary strata of this belt, scarcely admits of doubt; but that some of them are newer is also probable. Age.

Blocks of porphyry strew the shore road immediately north of Guysborough. Guysborough.

At Bigsby Head, to the southward, a mass of blackish, greenish, reddish and bluish amygdaloid, full of veins of calcspar, and holding specular iron and epidote, is in contact with altered sandstone and conglomerate west of the head of Carding-Mill Brook, in Tovy Brook, and other streams of the neighborhood; trap and diorite are associated with purple fragmental slate and compact porphyritic felsite. Iron ore.

Toward the eastern end of Rocky Lake are reefs of pinkish and greenish, mottled hæmatitic and calcareous trap in contact with flinty, altered red slates. At the eastern end of Grant Lake are blocks of purplish felspar-porphyry, veined with quartz and spotted with chlorite and specular iron; and on the wood road from this lake to the shore, these rocks are in place. On the lake south-west of Grant Lake are ledges of greenish, pyritous, fine-grained, calcareous quartzose and chloritic diorite, in contact with light-gray argillite. On other lakes of the vicinity, at Erinville, Glencoe, North Branch Lake, McAllister and Roachvale Brooks, the trap, diorite and felsite present few points of interest.

The frequent occurrence of veins and blotches of specular iron ore in connection with volcanic rocks leads to the conclusion that this ore owes its origin to them. At the Erinville iron mine, wedges and veins of ore are found in diorite, but also brecciated with a cream-white clay-rock. Specular iron ore.

Large outcrops of crystalline diorite cross the road south of Cuddihy Lake and the path from the iron mine to the shingle-mill at Glencoe. About half-a-mile out on the road from Erinville to Giant Lake, volcanic breccia and chloritic trap occur; and a small dyke of epidotic diorite about a mile east of Giant's Lake; with others in the neighborhood of Argyle. Giant Lake.

McNaughton Brook shows several junctions of volcanic rocks with Devonian strata. These latter, below the stillwater, consist of dark bluish-gray flinty argillite, and are in contact with light-gray amygda- McNaughton Brook, South River of Antigonish.

loid, perhaps continuous with that of the road. The amygdules are principally of calcspar or of yellowish agate-like quartz, chlorite and other minerals. Lower down, greenish compact diorite and whitish-gray granular quartz-felsite intersect micaceous sandstone, coarse grit and argillite showing impressions of *Calamites*. Still lower, knobs of light-colored trap extend nearly as far as a small brook from the west; immediately above which is gray granular quartz-felsite, succeeded at and below the brook by greenish trap, which again passes into compact porphyritic felsite or quartz-felsite, and into obscure granite. Lower down, light-gray, flinty, porphyritic quartz-felsite, with small spots of bright-colored vitreous quartz scattered through its mass, cuts highly altered sandstone or quartzite, succeeded again by light greenish-gray felsite, made up of fragments two inches and more in diameter. The greenish and gray plant-bearing flags and shales occur a few yards lower at a bridge on a farm road. A short distance below, trap and quartz-felsite are again seen, also at the foot of the gorge, and again to the north-eastward of the brook, as defined on the map.

5. *Dykes in Silurian and Devonian Rocks.*—The few intrusions among Silurian sedimentary strata have been all noticed. One of the most interesting is that west of Indian Brook, near Cape George, where red crystalline syenite and greenish, fine, calcareous diorite, themselves intimately mixed, containing porphyritic and globular masses, displace and are mixed with gray quartzite, probably Silurian, like the unaltered fossiliferous rocks of the immediate vicinity, but possibly older.

Cape George.

South River Lake.

On both sides of South River Lake are large outcrops of coarse hornblendic diorite. In some of the branches of McPhee's mill-brook, diorites are associated with amygdaloid. At the head of Polson's or Copper Lake, whitish coarse quartz-felsite, a granite without mica, is abundant. On the opposite side of the lake, running 83° from the shaft-house on the hill at the mine, and also at the road, a ridge of reddish and gray trap, fine-grained and obscurely amygdaloidal lies between a belt of wet lowland on the south, and the outlet of the lake on the north. Near the outcrop of whitish marble is a ledge of rock either igneous or so metamorphosed as to be irrecognizable as sedimentary. It should be remembered that here, as in other places, the volcanic areas on the map represent rather the points where such rocks have been seen than their extent and the intricate line of their contact, which can seldom be closely indicated.

Polson's Lake copper mine.

Lochaber copper mine.

Near the College copper mine, whitish granular diorite or granite, like that of Polson's Lake, breaks through purple argillite. In the brook running from the little lake in this vicinity are many blocks of greenish-gray, white weathering, fine amygdaloid, but none in place.

On the road from Lochaber to John Carroll's, the epidotic, quartz-veined diorite, containing blotches of specular iron, is doubtfully newer than the Carboniferous limestone.

6. *Lower Carboniferous Volcanic Rocks.*—Numerous dykes cutting Carboniferous conglomerate at McAra's Brook and on Cape George peninsula, have been described in connection with that formation. At Arisaig pier, a black trap, probably an extension of that of McAra's Brook, cuts the felsites, and extending along the shore outside them is seen at other points to the eastward: it is amygdaloidal and contains green serpentinous spots. **Arisaig.**

A pillar-rock of greenish-black amygdaloidal, spheroidal trap occupies the short piece of rocky inaccessible shore south of Ballantine Cove. Most of the amygdules are calcspar, and a bright-red soft mineral is in the veins. The trap of the small dykes northeast of Livingstone Cove is raven-black and greenish-gray, veined with calcspar. One of these dykes, about twenty feet in width, runs 156° with a north and south, vertical obscure lamination, scarcely altering the reddish coarse Carboniferous conglomerate, which must not be confounded with the flinty conglomerate and older system of dykes on the iron bound coast further west. **Pillar rock.** **Livingstone Cove.**

SURFACE GEOLOGY.

The prominent mounds or accumulations of drift materials along Malignant Brook from Maryvale chapel northward, on the Ohio and other rivers, and at Antigonish, have been described by Dr. Honeyman,* who has also given many particulars concerning the flats on the banks of the rivers, the deltas at their confluence, the large tracts of fine arable land in the intervales of Beaver Meadow, South and West Rivers, Right's River, James River, Brierly Brook and the great intervale upon which the town of Antigonish is built. Less attention has naturally, however, been paid to the superficial deposits than to the more interesting and important rocks which underlie. "The geology of this county, and the physical features, or hills, lakes, rivers, uplands and intervales which largely originate from its geology, constitute Antigonish the finest agricultural county in Nova Scotia." **Antigonish county.**

A section of stratified sand and gravel, resting on drift in a bank on the shore a little to the eastward of Merigomish Harbour, is given by Sir J. W. Dawson.† **Merigomish.**

On the Canso road east of Guysborough is a great ridge of sand and **Guysborough.**

* Trans. N. S. Inst. Nat. Sc., Vol. I., p. 118, Vol. III., p. 321, Vol. IV., pp. 75 and 79, and Vol. VI., pp. 315 and 325.

† Acadian Geology, p. 81.

Sand and gravel-ridges and mounds.

gravel known as the Gravel Pit, and near Halfway Cove on the upper side of the road, a deep hole called the Punch Bowl. Banks twenty-five feet high line the road on the southeast side of St. Mary's River between Whidden's ferry and Glenelg; others seventy-five feet high occur at North Lochaber; and about Barney's River, curious knolls or mounds of sand and gravel are numerous, the half barren pasture-land between the river and the shore being also very pebbly. On the railway between Avondale and Piedmont, are great banks of drift gravel; and between the road at William Murray's and the river, two long hogsbacks. A much more prominent hogsback, crossing the road, runs into the meadow opposite Thomas Leadbetter's at the upper settlement of Barney's River. It is composed of layered sand and gravel, the former used for making mortar; is eighteen feet high on the west side of the road, but flattens out to the eastward. Near the Round Lake of Cole Harbour River, north-west of Port Felix, is another well-defined "whale's back" in a sigmoid curve; it is about half a mile long, runs a little east of north and at the northern end terminates in two branches. It is composed of sand and gravel, rising about fifteen feet or more above the valley on either side, with a cow-path along its narrow top. In Hyde Brook, a branch of Salmon River east of Guysborough, a bright rusty conglomerate, apparently recent and composed of the pebbles of the brook somewhat strongly cemented by yellow ochre, sometimes assumes an indian-red color and may possibly be Lower Carboniferous. A mile and a half east of Sandy Cove, about six feet of rusty and dark conglomerate are seen in a little brook, the rusty cement being apparently accumulated from the sand and gravel, and the dark streaks from vegetable matter. In Delaney Brook, a similar conglomerate, horizontally bedded, contains many fragments of the dark slate found in the brook; and on the shore of Crow Harbour near John Ehler's, and again near the head of tidewater in Halfway Cove Brook, is a conglomerate, probably also derived from drift detritus.

Hogsbacks.

Conglomerate.

Ice grooves.

The following is a list of the more important observations of glacial striæ in this region, some of which are on finely polished rocks beneath twenty feet or more of sand, gravel and boulders:—

Whitehaven, S. 13° E.; well marked and seen in several places.
Parker Point, S. 4° E.; rocks polished.
Steep Creek, about S. 42° E. or parallel to the Strait.
North Canso, S. 30° E.
Cape George, near the school, S. 50° E.
Greendale, S. 70° W., on rounded, upright faces.
Livingstone Cove, S. 85° W., on sloping, polished faces.
Afton road, south of Wallace Lake, S. 15° E.

Lochaber, S. 7° E., near foot of the lake.

Lynch road, S. 44° W., and another not far distant, S. 58° W.

Upper Black Brook Lake, East River St. Mary's, S. 8° W., on rounded, polished rocks covered by ten feet of gravel at the outlet of the lake.

Large blocks and boulders are seen in many places far removed from the beds from which they have been derived, often isolated on little mounds of sand and gravel. Raised beaches* fringe many of the Guysborough lakes. Tracadie Lake has one, composed of large blocks of sandstone so arranged as to resemble rough masonry, while other parts of the shore are covered with fine rippled sand. **Boulders.** **Raised beaches.**

Sand-beaches are numerous on the sea shore as shown on the map. That at the mouth of Pomquet Harbour consists entirely of sand in undulating hills and hollows, nearly barren, but with a few scattered trees and bunches of grass. Great and important changes naturally take place in the position of these easily moved materials. The mounds of the eastern beach of Roy Island, for example, shown on the Admiralty charts, have been levelled, the beach at the west end lengthened, and a patch of lowland at the northwest corner removed. The inner shore of the island is all low and much of it marshy. A breach was made in the bar by the August gale of 1873, but was again closed by the sea within two or three days, and teams cross from this so-called island to the mainland even at high tide. At the base of Colquhoun Point is a beautiful beach for bathing, and there are many others on these shores. From the eastern end of the long beach, a bank of sand fringes the woodland nearly to the entrance of Merigomish Harbour. **Sand-beaches.** **Changes made by the sea.** **Roy Island.**

Springs, often containing various salts in solution, rise from the ground in many parts of this district, particularly where the underlying rocks are of the Carboniferous limestone and gypsum formation. At Taylor's road and on the road from Pomquet Forks are several strong salt springs, near one of which, in the intervale of Pomquet River, is a deposit of bog manganese. At Big Marsh in Hallowell Grant is the spring from which the water came that was analyzed for Sheriff Hill by Mr. Hoffmann.† In the country about Ashdale and Dunmore are many springs. Some of the plaster pits are fed by springs; others derive their supply of water from the surface. One of these pits in the neighbourhood of Ogden Pond is said to contain snow all the year round. **Mineral spring** **Hallowell Grant.** **Plaster pits and ponds.**

Near the house of Michael Gillis, Dunmore, is a sink-hole, in which, at the time of my visit, the surface of the water was forty feet below the surrounding country, and said to be very deep in the centre. The hole is about one hundred and fifty yards long and seventy-five yards

* Acadian Geology, p. 36.

† Geol. Survey Report for 1885, p. 15 M.

wide, and has water-lines at short intervals round its hopper-shaped basin. On the railway near James River, are other remarkable plaster pits and ponds of considerable size. East of Brierly Brook railway station, on the road to Antigonish is a strong, cold, saline spring, in broken plaster land.

At New Strathglass, a very strong spring gives rise to a branch of James River. It is cold, fit for drinking, and comes probably from an adjacent valley which, except in uncommonly wet weather, is dry.

Another spring below the Marsh settlement, forms a large branch of Middle Barney's River, coming out of the ground at George Clunes' house.

Dunmaglass.

A mineral spring, much resorted to, occurs on Donald McEachern's land in the Hollow near Dunmaglass post-office; the water has not been analyzed.

Springs, probably of similar composition and greatly relished by cattle, are found on Barney's River at Avondale and at the mouth of Bear's Brook, oozing from Pre-Carboniferous rocks.

At the bridge near the mouth of Anderson Brook, a small brook deposits yellow ochre, no doubt derived from the sandstone of the neighborhood; and similar ferruginous springs have been already mentioned as occurring in other districts.

Sutherland's River.

Immediately below Park's mills in Sutherland's River is a saline spring which deposits yellow ochre. Another occurs in the bed of the river a short distance above the mills. These and the salt springs in the neighborhood of Antigonish will be again referred to.

About one hundred and fifty yards south of the telegraph road, seventy-five yards west of the iron bridge over French River at Glenshee, is a large sink-hole on the west bank of the intervale. Beneath the sod, is a thickness of three or four feet of black mould, composed of roots and leaves; beneath this mould, an indefinite thickness of white clay.

Clay and peat.

Peat bogs are particularly numerous in the rocky country along the Atlantic coast; but no examination has yet been made of the depth and quality of the peat.

Infusorial earth and marl.

Deposits of infusorial earth and marl like those found in western Nova Scotia,* occur in many lakes of this region, some of which have been described by Principal McKay, of Pictou.

A little lake on McKay Brook, St. Mary's, has been drained to turn it into hay-land, exposing a bed of shell marl.

Scenery, Climate, Timber, Productions, etc.

Messrs. Jackson and Alger say in the short sketch which accompanies their map of Nova Scotia, published in 1841, that "it possesses some

* Acadian Geology, p. 34.

of the most varied and remarkable scenery in North America,. . . diversified with beautiful lake scenery and picturesque coast views, verdant hills and valleys and many flourishing villages." Scenery.

In Haliburton's History and novels, Gesner's Geology and Industrial Resources of Nova Scotia, Dawson's Acadian Geology, and a host of other books, frequent reference is also made to the scenic attractions of the coasts and mountains of this province.* The southern coast is bleak and barren, with sluggish brooks, lakes and marshes; and is almost uninhabitable, except for the fishing and mining, although there are many excellent harbours affording picturesque views among their numerous islands and bold, rocky headlands. In the northern part, the scenery is more attractive, and we again find the "cool clear rills trickling down the glades;" the views are more picturesque, and the numerous meadows form a pleasant landscape, the land being well irrigated by brooks, and on either side of which it rises in romantic boldness to a considerable height, but seldom approaches to the altitude of mountains. Atlantic coast Gulf shore.

The coast of Canso, Dover and the islands in the vicinity are wild and romantic, presenting to the ocean rough bold cliffs, mostly granite, the surface being either barren or supporting a few scraggy spruces, cranberries and other low-growing plants. The most northerly of the Cranberry Islands, called the Frying-Pan, is the home of innumerable sea-gulls. Extensive barrens lie between Canso and Tor Bay; but hay-marshes fringe some of the brooks, and small spots of cultivable land are found on the shore. Toward the head of New Harbour, mossy spruce land, interspersed with clumps of birch and maple, occupies the valleys and also some of the hills on which, however, much of the timber is blown down. Canso. Barrens.

The valley of New Harbour River to the head of tidewater, is very beautiful, the hills on either side being high. Above the salt water, it is wide and easy to follow. On Isaac's Harbour River, fine meadows and marshes occupy a narrow belt about the lakes, while higher up, the river flows through a well-wooded valley from which a large quantity of timber for shipbuilding has been obtained, but which is otherwise apparently unproductive. Good hardwood is found between the upper part of this river and Lawlor's Lake, and toward Country Harbour and westward, interspersed with barren tracts, which are also characteristic of the Canso peninsula, as of all the large areas where granite abounds. New and Isaac's Harbour Rivers. Ship-timber.

The scenery of the St. Mary's River at Melrose, is picturesque in its well cultivated meadows and numerous small lakes, enclosed by rough, woody hills. Many of the lakes which empty into this river are rocky and beautiful, bordered with hardwood and evergreens, inside which a Melrose. Lakes.

* Osgood's Maritime Provinces, page 334.

white line of blocks is frequently seen. Where brooks enter, however, the shores are generally low and marshy, and lagoons, difficult to cross, extend far upstream; the lakes are thus easily dammed for lumbering or other purposes, and much of the country, in their vicinity, is liable to be flooded after a heavy rainstorm. A great freshet, on September 12th, 1882, flooded all the mines near Sherbrooke, and for a time converted a great part of Goldenville into a lake.

Rivers.

One of the roughest rivers in the country is the picturesque portion of the East River of St. Mary's at Rocky Mountain, where the gorges and high overhanging cliffs present during a freshet a scene of wild and terrifying grandeur.

Picturesque boulder.

Sutherland's Brook is a stream of great beauty, with its foaming cascades, its pools, and woody banks. Not far above its mouth, a boulder of conglomerate forms a little island, crowned by a clump of spruces, one of them nine inches in diameter. The conglomerate is like that of Arichat; the cliffs are of gray argillite and quartzites, sometimes finely rippled.

Holy Hill.

All the branches of the East River about Holy Hill, on the contrary, wind sluggishly among alders and marshes in half barren land, with little fall and few rock outcrops.

South River Lake and Lochaber are singularly beautiful. Of the latter, the late Honorable Joseph Howe thus speaks in his poem *Acadia*:

> Winding in graceful folds, 'twixt hills that rise
> On either side, the fair Lochaber lies."

McPhee's mill-brook.

On the brooks flowing into this lake, and on several branches of South River, scenes of rare beauty are afforded, one of the most remarkable of which is the rocky gorge above the lower dam in McPhee's mill-brook.

Pomquet and Tracadie.

The brooks of the well settled districts of Pomquet and Tracadie, are, as a rule, tame and uninteresting, exceptions being found, however, in certain picturesquely rocky portions of the Monastery Brook, and of Tracadie, Pomquet, Black and Afton Rivers.

Ohio Mountains

Brooks flow from the Ohio Mountains, where they rise from springs and small marshes, as gentle, often steep, but never dangerous mountain-streams, in whose sheltered gorges ferns are green till the middle of November. The land at the head of St. Joseph Lake is hilly, and broken by limestone and plaster which form pits, ridges and little knolls. Callahan Brook, with its picturesque, rocky walls of red syenite and slate, its falls and deep, narrow gorge has been already described. Many of these brooks and lakes abound in trout, which

Callahan Brook

Trout.

differ greatly in size and color, even in waters no great distance apart, as for example in the two Black Brook lakes, in the uppermost of which the fish are of a fine red color, whereas, in the lower, they are black—a circumstance perhaps due to the color of the shores and bottom which are largely composed of red syenite at the upper lake, but at the lower of black slate.

The Sugar-loaf at Antigonish, and the hills on the Gulf shore, command fine and extensive views of the surrounding country and to seaward. Arisaig Brook, the lower part of Doctor's Brook and its east branch run in deep and beautiful valleys, like some of the Mabou rivers, as shown in Mr. Weston's Arisaig photographs. But there is in the scenery of this district no more striking feature than the Hollow or "Bruin's Highway," a pass or gateway extending along the northern boundary of the Cambro-Silurian rocks from McNeil's Brook to Bailey's Brook, nowhere wide and comparatively level, although the hills, particularly on the south, are high.* **Antigonish hills and valley.** **The Hollow.**

The scenery of Marshy Hope valley resembles that of certain Cape Breton glens; but the outlines are usually tamer and less attractive. James River, Brierly Brook and other streams of the neighborhood afford wild and beautiful views, like those of Margaree. Brierly Brook flows with two fine falls of ten feet each, through a narrow gorge with high perpendicular walls. The celebrated falls of James River are best seen from above on the left bank, for from below they can be seen only in part. "Green quartzite forms an elevated peak which rises abruptly above the falls. The water flows in great volume over precipitous rocks, and from a height of about one hundred feet, into a capacious basin, the whole forming a scene of impressive grandeur." † **Marshy Hope.** **James River falls.**

A cave, one hundred feet long and six feet wide, in the limestone of McLellan Brook is quaintly described by Gesner.‡ A small stream of pure water runs along the floor, and rude overhanging masses of rock form the walls and roof. A succession of fine falls occur in the gorge of Sutherland's River at Park's mills, among cliffs rising to a height of more than fifty feet. The lowest falls over two steps of one and two feet, into a deep, rock-bound pool, while above there are two cascades, aggregating twenty feet, which cut through the rocks in three separate gorges. **Cave.** **Falls of Sutherland's River.**

"The beautiful valleys and hills which surround the thriving village of Sunnybrae, on the East River of Pictou, render it worthy of its name, and one of the most picturesque spots in Pictou county." **Sunnybrae.**

* Trans. N. S. Inst. Nat. Sc., Vol. IV., pp. 54 and 57.
† Dr. Honeyman in Trans. N. S. Inst. Nat. Sc., Vol. I., p. 110.
‡ Geology of Nova Scotia, p. 135.

Soils.

Reference has been made in this report to the character of the soils yielded by the various underlying rocks, and to their capacity for producing grain and other crops. The land underlain by Pre-Cambrian felsites and schists is generally more or less sterile; that of the Cambro-Silurian districts is hilly and rough, but productive. The Silurian soils are fairly good, but too clayey; the Lower Devonian and Carboniferous conglomerate are often rocky and barren; whilst the Upper Devonian soils are said to be, in some cases, superior to those of the Carboniferous limestone, the highest red beds being very productive, as shown by the thriving farms at Beauly, Lochaber, South River, Vernal, Marydale and elsewhere.

Upper Devonian.

Carboniferous limestone.

The soil derived from the Carboniferous limestone is rich, loamy and calcareous in the neighborhood of limestone; but the clay-land derived from shales, as at Tracadie and Heatherton, although free from stones, is wet and less productive than the more stony land of the rear. Between Pitcher's Farm and West River, only a few inches of soil cover a shaly rock; consequently the land is bad and in great part still under forest, although comparatively level. Considerable tracts of barren occur on the peninsula north of Antigonish, underlain by Carboniferous conglomerate and associated rocks, but with few other exceptions, all the land in this county is fit for cultivation. But between the East and West Rivers of St. Mary's, nearly all the country underlain by this formation and by Devonian rocks, is irreclaimably barren, dry and rocky, covered with blocks of whitish flinty sandstone and grit. In part, this barrenness is no doubt due to bush fires which have destroyed much valuable timber; but the gray sandstones do not seem to possess the substance necessary for a luxuriant growth of vegetation, so that the injury done by the fire is not repaired, the forest being replaced by shrubs and mosses, or the bare surface of the rock left without even a covering of moss. The mossy spruce- and tamarac-land, the pools and mossy marshes bordered by scraggy spruce, the sluggish brooks, lakes and other uninteresting characteristics of this district have been frequently adverted to.

St. Mary's barrens.

Wild flowers.

But whether "waste or woodland, hill or plain," the wild flowers are there, hidden away among the trees, making bright the open barrens by their charming variety of color and form, trailing in the streams or rising from the water of marshes and ponds. A pretty little flower the water Lobelia (*Lobelia Dortmanna*)* was found growing in the upper Black Brook Lake; a Purple Fringed-Orchis (*Habenaria fimbriata*), and white water-lilies (*Nymphæa odorata*) are seen in some of the brooks; cranberries abound in the marshy lakes. In Gunn's Lake, the marshland is golden with the fragrant and beautiful little Hood-shaped

* Determined by Professor Macoun.

Bladder-wort (*Utricularia cornuta*), associated with fly-catching plants. The so-called lily of the valley (*Maianthemum Canadense*) is also abundant in moist woods. In the bed of a sluggish brook, flowing from marshes at John Chisholm's, near the head of McPhee's mill-brook, are large numbers of the white water-crowfoot (*Ranunculus aquatilis*, var.) On some of the streams of Antigonish, as for example Graham Brook, the ferns sometimes attain a height of seven or eight feet. Interesting collections of the plants of this region, made by Messrs. Faribault and Robert, have been examined by Professor Macoun.

The seasons do not differ materially from those of the country north and east of the Strait of Canso. That of 1886 was very early, the mayflower (*Epigæa*) being in bloom on April 15th, and the white water-lily (*Nymphæa odorata*) on July 10th; whereas the latter was not in flower on Flynn and Gavin Lakes till August 8th in 1884. **Seasons.**

Raspberries and blueberries were ripe at Guysborough Intervale on August 8th, 1884, and an extraodinary crop of wild strawberries was ripe at the College on July 10th, 1885, the dewberry having preceded them several days.

The crops are similar to those of Cape Breton, the land in the northern part of the mainland being, however, better settled and in a higher state of cultivation. Much interesting and valuable information about the climate, resources, scenery and population is contained in Haliburton's History of Nova Scotia. Wheat ripens on Roy Island, **Wheat.** Big Island and along the greater part of the Gulf shore, but not always in the interior. A large quantity of ton timber is shipped to England chiefly from Guysborough Harbour, but the woods of the greater portion of the country are small, and barely supply the local demand for lumber. The animals are the same as in Cape Breton. Moose and bears were once common on the barrens of St. Mary's, the former are now scarce, although still occasionally killed. The population of Guysborough county is 17,808,* of Scotch, English, Irish, French and German descent, with 900 Africans; 1601 are fishermen, and 1568 farmers, with a floating mining population. Antigonish county has a population of 18,060, of which two-thirds are of Scotch descent, the remainder French, Irish and English chiefly, with a few Africans; 3256 being engaged in farming, 43 in fishing. Of the 35,535 inhabitants of Pictou county, six-sevenths are of Scotch descent, the remainder chiefly English and Irish; farmers, 4806; fishermen, 15; but many of the farmers fish also. **Population.**

In Guysborough, the number of acres under cultivation for grain, is 682; for roots, 1,996; for hay, 15,881. The annual yield of wheat is 6,529 bushels; of barley, 4,152: of oats, 42,988; buckwheat, 11,720; **Produce of Guysborough.**

*Census of 1881.

potatoes, 191,259; turnips, 12,016; of other roots, 2,062; and of hay. 20,512 tons. Butter, cheese, wool, cloth, cattle, sheep, pigs, horses, and maple sugar are also produced, but very few apples or other fruits. The value of the fur procured is $1,565. Pine,—square and in logs,—oak, tamarac, birch and maple are exported, and also masts, spars, staves, tan-bark and cordwood. Much ship timber is still taken out of the forests.

Of cod, there are taken 30,943 quintals; 9,369 of hake, haddock, and pollock; of herring, 17,276 barrels; of gaspereaux, 1,293; of mackerel, 13,117; besides halibut, salmon, eels and trout; 13,874 gallons of fish-oil are produced; and 520,405 pounds of canned lobsters.

Antigonish. The number of acres under cultivation in Antigonish is 3,640 for grain; 3,363 for roots; 36,141 for hay. The yield of wheat is 41,687 bushels; 10,811 of barley; 153,675 of oats; 1,244 of peas and beans; 15,228 of buckwheat; potatoes, 319,946; turnips, 26,400; other roots, 1871; 41,164 tons of hay. Butter, cheese, cloth, a little fruit and maple sugar, horses, cattle, sheep, and pigs are also exported. The value of the furs is $356. The same woods are exported as from Guysborough and Pictou, with the exception of tamarac and oak.

Of cod there are taken 2,087 quintals; of hake, haddock and pollock, 815; 999 barrels of herrings; 100 of gaspereaux; 3,084 of mackerel; besides salmon, eels, trout and oysters, and there are 970 gallons of fish oil made.

Pictou. In Pictou county 11,647 acres are under cultivation for grain; for roots, 4,182; for hay, 39,913. The yield of wheat is 114,741 bushels; of barley, 14,459; oats, 345,591; buckwheat, 29,059; peas and beans, 2,362; potatoes, 486,444; turnips, 71,775; other roots, 5,086: hay, 45,715 tons. Butter, cheese, cloth, wool, cattle, sheep, pigs, and horses are also exported; apples, grapes, plums and other fruits grown in large quantity. The furs are valued at $657. The woods exported are the same as those from Antigonish.

Pictou county furnishes the market with 1,440 quintals of cod; 16 of haddock, etc., 1,287 barrels of herring; 109 of gaspereaux; 398 of mackerel, together with salmon, shad, eels and trout; 196 barrels of oysters; 524 gallons of fish-oil and 394,300 pounds of canned lobsters.

Economic Minerals.

The occurrence of various useful minerals and metallic ores has been already referred to, and will be more fully discussed in the following pages. These minerals are well illustrated by the collections in the museum of the Geological Survey at Ottawa, and in the provincial museum at Halifax.

Coal.—The small pipes and seams of coal in the sandstones of the East and West Rivers of St. Mary's, at French River, South River and elsewhere, are of no economic value, and need not be enumerated; nor will the vain search for coal at various points, as at Kerrowgare and Arisaig, in black Silurian slates, be again referred to. Coal.

The discovery of a seam of coal, eight inches thick, at Pomquet Harbour, and of pieces of coal and the remains of vegetables on the North River of Antigonish, was noticed by Gesner* in 1836; and Haliburton adds, that limestone is found about a mile to the westward of the former. Of late years, several pits have been sunk at Peter Dion's, where the coal dips N. 24° W. $< 20°$, associated with crumbly gray sandstone and greenish and gray argillaceous shale, and underlain by underclay full of *Stigmaria*. The coal seen in pieces on the shore, is in part bright and good, but in part very pyritous. A boring in the water not far from the bank, is said to have cut: rock, 5 feet; coal, 2 feet; resting on rock not bored. Pomquet.

No seams of workable coal appear to have been found on the peninsula north of Antigonish, the black shales there exposed having apparently been mistaken for coal,† into which they pass at several points; but from many of the openings not a trace of good coal has been obtained. Mr. Campbell ‡ has clearly shown that these oil coals and shales underlie the Carboniferous limestone at Big Marsh; he divides them into two groups, the lower seventy or eighty feet in thickness, including twenty feet of good oil shale, five feet of which are curly cannel, rich in oil; the upper, 150 feet thick, in immediate contact with the limestone, containing a large percentage of oil. The pits dug in search of coal in and about Big Marsh, are shown on the map. The black shales are associated with light-gray micaceous shale and sandstone, full of impressions of broken plants. In the report of the Commissioner of Mines for 1868, page 21, a return is made of $682.50 expenditure for preparatory work in driving a tunnel into the face of a hill for the purpose of cutting the seam of coal. An additional expenditure is returned of $590 next year, but the presence of faults near the crop of the seam is said to have impeded progress. In 1870 considerable difficulty is said again to have been experienced in consequence of the disturbed state of the strata, a series of faults having thrown the seam out of its regular position, and necessitated much extra work in drifting.§ At two of the pits, on the Beaver road, a black, very bituminous shale passes into gray, rusty, crumbly shale, glistening with mica and containing obscure plants. Coal has

Hallowell Grant

Coal below the Carboniferous limestone.

* Geology of Nova Scotia, p. 142.

† Acadian Geology, p. 349; Trans. N. S. Nat. Sc., Vol. VI., p. 70; Gilpin's Mines of Nova Scotia, p. 14.

‡ How's Mineralogy, pp. 28 and 34.

§ Rutherford's Report.

also been sought in the black, bituminous, carbonaceous shale near Ogden Pond. On Graham Brook, pits have been dug in a coaly crumbling rock with steel-gray, nodular, ferruginous, argillaceous shale, which contains plants, and which is associated with conglomerate, and underlies a gray limestone. On Huggan mill-brook, near Cumming's furniture factory, at Piedmont, several pits have been dug in search of coal, in gray and greenish-gray shaly sandstone, of Millstone Grit age, full of carbonized plants and associated with reddish-gray striped sandstone, which has been quarried for building. Streaks of coal, six inches in thickness, found, it is said, in these rocks, seem to be only carbonized tree trunks.

Ogden Pond. Piedmont.

The so-called coal mine of Lower South River is described on page 82 P; and the Permian coal seam of Big Island, on page 95 P. The borings made some years ago in the small seams of East River, north of the Pictou coal-field are described by Mr. Henry Poole.* In the report of the Commissioner of Mines for 1873, page 15, it is stated that a bore-hole was put down 500 feet at Sutherland's Point, north of New Glasgow, which reached shales very similar in appearance to those of the coal-bearing basin to the south but which were more probably those of Mr. Poole's section. In 1874, the bore-hole was extended to a depth of 734 feet, when mottled marls were struck. Another boring, 534 feet deep was made at Hardwood Hill, the measures passed through being fire-clay and freestone.

Lower South River. Merigomish. Pictou Harbour

Vivianite.—This beautiful blue phosphate of iron is reported by Professor How† in small quantity near the surface at Antigonish.‡

Antigonish.

Bog Iron Ore.—Bog ores are found in several places in small quantity. A specimen from Antigonish county analyzed by Dr. How,§ contained "45 per cent. metallic iron with 18.30 water, about 7 of clay, 5 per cent. organic matter, and a decided but not unusually large amount of phosphoric acid." A specimen from a small deposit near French River yielded to Mr. Gilpin || 46.56 per cent. metallic iron, 11.60 water; manganese 5.89, clay 15.43, with traces of sulphur and phosphoric acid.

French River.

Clay-Ironstone. Beds of clay-ironstone, from six inches to four feet in thickness, are noticed by Mr. Gilpin¶ as numerous among the Carboniferous strata of French River; and an analysis of one of them gave: metallic iron, 25.16 per cent., clay 61.52 per cent. and traces of sulphur and phosphoric acid. The spathic ores of Polson's Lake, are

Polson's Lake.

* Trans. N. S. Inst. Nat. Sc., Vol. I., p. 86.
† Mineralogy of Nova Scotia, p. 109.
‡ Trans. N. S. Inst. Nat. Sc., Vol. VI., p. 325.
§ Mineralogy of Nova Scotia, p. 102.
|| Nova Scotia Mines. p. 64.
¶ Nova Scotia Mines, p. 64.

described at page 119, that of Sutherland's River in the Geological Survey Reports for 1866-69, p. 441, and for 1873-74, p. 238. Sutherland's River.

Brown Hæmatite.—An analysis of a specimen of ore from Lochaber, collected by Dr. Honeyman, yielded* nearly 48 per cent. metallic iron, water 11.12, sesquioxide of manganese 4.73; siliceous gangue 13.86, and traces of phosphoric acid, lime and magnesia. Carbonate of iron, micaceous iron ore and copper ore are stated by Dr. Honeyman to be also widely but thinly distributed among the Devonian Slates, from which this specimen was obtained. Lochaber.

The iron ores of the East River of Pictou have been described by Gesner,† Dawson,‡ How,|| Hartley,§ Honeyman,¶ Poole,** Gilpin,†† Harrington,‡‡ and others, but will not be here referred to, since the region in which they occur has not yet been thoroughly examined. East River of Pictou.

Red Hæmatite and Specular Ore.—The wide range and distribution of these valuable ores of iron in the counties of Guysborough, Antigonish and Pictou, in beds, veins, strings, blotches, films, and specks, in all the rocks from the highest to the lowest, has been frequently pointed out. Some of the outcrops would seem to indicate the presence of large bodies of ore, but none of them are now vigorously worked.

At Bigsby Head, east of Guysborough, a vein of specular ore runs 244° among trap and purplish felsite. Guysborough.

A most promising deposit of specular iron has been worked near Erinville by the Crane Iron Company, of Philadelphia, under the management of Mr. T. M. Williams, of Mine Hill, New Jersey, to whom I am indebted for many of the following particulars:—To test the ore, a shaft was sunk fifty feet, from the bottom of which a drift was extended twenty-five feet through the ore to a wall. Another tunnel was driven sixty feet north-east in the ore, and a third south-east thirty-five feet, also in hæmatite; while in an open cutting, another band was found to extend twelve feet in a south-easterly direction. On the top of the back or ten feet vein, are masses of quartz, full of long, narrow crystals, crystalline fragments of the ore, and a little iron Erinville.

* How's Mineralogy of Nova Scotia, p. 99.

† Geology and Mineralogy of Nova Scotia, p. 59; Industrial Resources of Nova Scotia, p. 258.

‡ Acadian Geology, p. 591; Supplement, p. 94; Canadian Naturalist, Vol. VII., p. 137, and Vol. IX., No. 6; Report of the Pictou Coal and Iron Co., 1875; Report of the American Association, 1879.

|| Mineralogy of Nova Scotia, p. 97.

§ Geol. Survey Report for 1866-69, p. 182.

¶ Trans. N. S. Inst. Nat. Sc., Vol. II., Part 4, p. 67; Vol. III., p. 171; Vol. V., p. 204.

** Reports of Commissioner of Mines for 1872, p. 36; for 1874, p. 49; 1875, p. 61; 1876, p. 57; and 1877, p. 43.

†† Nova Scotia Mines, p. 64.

‡‡ Geol. Survey Report for 1873-74, pp. 214, 223, 229, and 259.

pyrites. Other openings have been made about one hundred yards, 232° from the main shaft, in all of which more or less ore was cut. The walls of the veins seem to be in every case composed of greenish, dioritic, felspathic, trappean and brecciated rock; but, at the time of my visit, Sept. 30th, 1882, they were not well exposed, and no work has been done since. About three thousand tons had been extracted at a cost of fifty cents per ton, the cost of hauling to a shipping place at Guysborough being $1.50, and the price at the time $7 to $8 per ton in the American market, where it was used for lining puddling furnaces.

At another opening, on Thomas Kent's claim, about a mile to the westward, specular ore has been found in wedges and veins, brecciated with cream-white claystone and quartz, in blotches and veins, with crystals of pyrites, in two pits not far apart, near one of which is a strong, ferruginous spring. A vein, six or eight inches thick, occurs in compact, greenish-gray soft rock, probably an altered argillite, but without apparent bedding. In the neighborhood are great outcrops of dark-gray trap in contact with conglomerate, the ore being scattered through all these rocks.

Guysborough River.

In Guysborough River, immediately east of Mink and Atwater Brooks, is another deposit of specular iron, which has been mined in a flinty, quartzo-felspathic rock, containing large crystals of calcspar. The ore forms a sort of breccia with a ferruginous calcspar, and is also veined with it, being itself a vein six feet wide, which runs 65°, but is not well exposed. Some parts contain a large percentage of iron pyrites, and very little of it is quite free from this impurity. No undoubted volcanic rock is seen, the grayish-white claystone being probably a mixture from the vein.

Giant Lake.

Iron ore is said to have been found at Angus McIsaac's, Giant Lake. but nothing is yet known about it.

South River.

Near South River and Vernal, the Devonian slates and sandstones contain traces of specular iron ore. In a pit west of the Vernal road, the quartz-veins, which penetrate a flinty quartzite, are associated with veins of ore, seldom exceeding a quarter of an inch in thickness, but very numerous, reticulating in the cracks of the quartzite, sometimes without the quartz.

Caledonia Mills

At Duncan McDonald's, Caledonia Mills, a shaft was sunk through compact sandstone, spotted with a considerable quantity of iron ore which is also present as films in the joints, and associated with a breccia composed of specular iron, red hæmatite and spots of felsite.

South River Lake.

In a small brook on the west side of South River Lake, dark-gray, coherent, argillaceous sandstone is cut by a vein of quartz, six inches thick, holding half specular iron. It runs 4° and is traceable for some distance in the bedding. Other small and unimportant deposits of this neighborhood and Lochaber are indicated on the map.

In a small brook which flows from the back settlement of Arisaig to the confluence of the east and west branches of Doctor's Brook at John and Andrew McDonald's, red hæmatite, six feet thick in a north and south direction, shows itself in the bank among outcrops of fragmentary rocks and slates; but whether as a vein or bed was not determined. The ore is in part excellent, but somewhat variable in composition. About fifty yards upstream from this outrop is another, said to be twelve feet thick, and smaller bands are stated to occur lower down. Other important deposits have been discovered between the back settlement and Doctor's Brook: one of these shows eight feet of good, coarsely oolitic hæmatite in a light-colored siliceous rock; another, six feet of ore among red slates. The numerous similar deposits of this neighborhood, perhaps, owe their origin to the proximity of syenite, diorite, and other igneous rocks.* On the new road from Doctor's Brook to Pleasant Valley, below the bridge on the brook, a band of rock, six feet wide, in a north and south direction is strongly impregnated with and passes into pure hæmatite. Near this and, perhaps, continuous with it, is the so-called twenty-four feet bed, in a greenish flinty sandstone. Measured from north to south, the breadth of ore-bearing rock is forty-one feet, the more northerly small vein being, however, separated from the other by about twelve feet of greenish-gray, banded, flinty quartzite, dipping 331° $<$ 63°, in layers one to eighteen inches thick, and in the thick bed are several of these bands, more or less lenticular, and, therefore, differing in thickness in different parts of the cutting. At one point, the hæmatite is said to have measured twenty-four feet of solid ore; but where best seen, the thickest layer does not exceed six feet, while to the eastward, all, except this and an eighteen inch band near it, may be said to be quite cut out or replaced by quartzite. The ore is oolitic and good, like that found elsewhere in the neighborhood; near it are reddish and mottled fragmentary rocks diorite, with veins of epidote, red concretionary, hæmatitic slate, and other similar strata. **Doctor's Brook.**

To the north-westward, a shaft twenty-five feet deep was sunk, some years ago, in trap showing traces of specular iron. In the small brook, which crosses the shore road east of McNeil's Brook, are two large outcrops of red hæmatite, about eighty-eight yards apart. The upper one shows about ten feet of pure hæmatite; the lower 15 feet, with "horses" of greenish flinty rock. **McNeil's Brook**

Immediately west of McNeil's Brook, near Angus Campbell's, is a bed of oolitic hæmatite, three feet wide, opened for twelve feet east and west, and separated by about forty-five feet of Cambro-Silurian slate, from another large indefinite band to the northward.

*Trans. N. S. Inst. Nat. Sc., Vol. IV., p.. 53.

Gulf road. West of the Gulf road, on the line between Angus McGillivray (Andrew's son) and Ranald McDonald, is an outcrop of fine red hæmatite, six feet thick in an east and west direction. Greenish diorite is in the vicinity, and the detritus indicates also the proximity of rusty-weathering, soft Cambro-Silurian slate.

Arisaig. The bed of hæmatite interstratified with the Silurian rocks of Arisaig is described at pages 44 and 48 P. It is probably that of which an analysis is given by Mr. Poole,* containing 52.34 per cent. metallic iron.

The Webster iron ore is a very siliceous, red hæmatite of varying richness, apparently a contact deposit between Silurian and Cambro-Silurian strata, like the Lower Carboniferous ores of Cape Breton.

Marshy Hope. At Marshy Hope, a small quantity of specular iron is found in connection with trap and Cambro-Silurian rocks, on the north side of and close to the railway, west of the Bear's Brook.

Avondale. Nearly opposite the post-office at Avondale is a red siliceous rock, not actually seen in place, but evidently underlying, which passes into an iron ore, apparently not rich enough to pay for working. It may indicate a patch of Devonian rock here, but is perhaps Lower Carboniferous.

French River. On the slope of a hill on the west side of a tributary of the East branch of French River that crosses William Irving's land twenty-eight chains south of the telegraph road, two miles west of Kenzieville, (Barney's River) is an outcrop of iron ore that may prove of importance. It lies at the contact of the Medina and Cambro-Silurian strata, and seems to be a mixture of trap and grit, passing in places into oolitic hæmatite of fair quality.

Bog Manganese.—The earthy and bog ores of manganese, largely used for paints, are found in small quantity as nodules and earthy beds in the soil in many places, as, for example, on the road to Goshen from the foot of Lochaber; on the telegraph road near Afton, where porous, rusty-weathering rock occurs in a swamp and stinking-pool; in Pomquet River, below John Chisholm's house; in Sutherland's Brook, immediately above the East River of St. Mary's; and on the hill south of the railway, west of Piedmont station.

Pyrolusite.—Large pieces of this ore of manganese are said to be found in the drift on the hill, four hundred yards south-east of Callahan's house, near the head of the Ohio settlement. It is also found, associated with iron ore, at the East River of Pictou.*

Copper Ore.—Ores of copper are widely diffused among all the geological formations in this region, but although large sums of money

* Report of Commissioner of Mines for 1876, p. 60.

† Gesner's Geology, p. 63; Geol. Survey Report for 1873-74, p. 230.

have been spent in developing some of the more promising deposits, none of these have yet realized the expectations of the explorers.

McAllister's Brook. The occurrence of copper pyrites in specks in dark slate, associated with the trap and syenite of McAllister's Brook, near Guysborough, was pointed out on page 53 P. **Erinville.** In the northwest branch of Salmon River,* about a mile above Erinville, an indefinite quartz-vein was mined twenty or more years ago for copper. A tunnel was driven a few feet into the west bank of the river, and a shaft sunk forty feet to meet it; but the vein was not cut in the shaft. It contains copper and iron pyrites and is associated with bluish-gray very coherent slates. **Mink Brook.** A minute quantity of copper ore occurs in the flinty Devonian quartzite of the Mink Brook, a tributary of the Guysborough River.

Polson's Lake. On Polson's or Copper Lake, east of Lochaber, fragments of copper and iron pyrites, sometimes three to five feet in diameter, in an impure brown hæmatite, are found in the surface gravel,† derived from veins near the junction of Devonian and igneous rocks. "Spasmodic efforts were for nearly forty years made to find the vein from which the boulders came. . . . At last, in 1875, a vein containing copper pyrites was discovered,"§ six feet wide, dipping north with the containing slates, and consisting chiefly of spathose ore, spotted with copper pyrites. In 1876 this vein was opened by a shaft twenty-five feet deep, "the mineral matter at the point opened being chiefly spathic iron ore, yielding 35.5 per cent. of metallic iron; it is spotted with iron pyrites. In 1879 two shafts were sunk about sixty feet, but work was then suspended. At a distance of one hundred and fifty feet along the vein, where the cover is reduced from twenty to five feet in thickness, another opening was made, and the width of the vein there determined to be eleven feet. The percentage of copper ore is said to have also largely increased." Fragments of the associated Devonian dark slates are enclosed in the vein-stone, and in places a crystalline rock is attached to a breccia and quartz occasionally mixed with the spathic iron. The land rises steeply from the road to the mine, and near the road, traces of specular iron have been found in spathose veins traversing greenish-gray and purplish argillite.

Two specimens of ore from this mine were examined by Dr. Harrington.|| The first taken from a considerable depth was found to consist of a mixture of copper pyrites, spathic iron ore and a little iron pyrites, containing 11.70 per cent. of copper, but no silver. "The spathic iron ore is pale brownish-gray in color, coarsely crystalline,

* How's Mineralogy of Nova Scotia, page 72.

† How's Mineralogy of Nova Scotia, p. 67; Dawson's Acadian Geology, p. 592; Supplement, p. 95; Trans. N. S. Inst. Nat. Sc., Vol. IV., p. 77.

§ Poole, Report of Commissioner of Mines for Nova Scotia for 1875, p. 64, and for 1876, p. 62.

|| Geol. Survey Report for 1876-77, p. 476.

and has a specific gravity of 3.61. It was found to contain 73.68 per cent. of carbonate of iron, or 35.573 per cent. of metallic iron."

"The second specimen was from the surface, and consisted of copper pyrites, pale iron pyrites, hydrated peroxide of iron, and some rock matter. It was found to contain 5.67 per cent. of copper." Further particulars concerning this mine, and that on the west side of Lochaber, will be found at pages 59 and 102 P.

Lochaber.

On the College lands, about two miles west of the foot of Lochaber, a shaft, said to be 85 feet deep, was sunk in 1876 in greenish epidotic, serpentinous diorite traversed by veins of quartz in which, as well as in joints in the diorite, occur large blotches of specular iron and copper pyrites.

Iron pyrites is sparingly present, and spathic iron is mixed with quartz as the vein-stone in one or two places. Some of the blocks from the veins are three feet thick, of quartz and diorite mixed; in them are vugs containing long crystals of quartz and beautiful leafy aggregations of specular ore. In many of the neighboring pits, purple Devonian argillite has been cut. The relations of the various rocks could not be made out at the time of my visit, work having been long suspended at the mines; but Mr. Gilpin* states that: "the deposits form a series of veins, cutting at oblique angles black and red shales and quartzites, and thrown for a short distance 30° out of an east and west course by a dyke, apparently containing talc and serpentine.

"The first vein met going east is about two feet wide. I have no details of its contents. The second vein, twenty feet distant, has been proved to a depth of eighty-five feet; it varies in width from five feet six inches to six feet three inches, and holds about 20 per cent. of copper pyrites, evenly distributed in talcose slate, greenstone and quartz, and micaceous iron ore. The third vein, 216 feet distant, is from one foot six inches to two feet wide, and holds copper pyrites, with erubescite in bands, with quartz and talcose greenstone. The fourth vein, 130 feet distant, is about five feet wide, and carries about 10 per cent. of rich ore, with much quartz. The fifth and sixth veins are respectively fifty and one hundred and fifty feet further east; they are about each three feet wide. . . . In these last, the micaceous ore has been to some extent replaced by carbonate of iron. . . . The sixth vein is gradually returning to its east and west course; and, at a further distance of three hundred yards, it has been opened again and proved to be four feet six inches wide; and, nearly half a mile to the east, on the strike of the vein, two small veins have been found, holding very good ore, and large boulders, proving the passage of the larger veins."

*Nova Scotia Mines, p. 78, and Quarterly Journal Geol. Soc., Vol. XXXIII., p. 751.

"The quality of the Lochaber ore is unusually good; the chief variety met is copper pyrites, with a small admixture of carbonate of copper and erubescite. An average of the large veins, gave on analysis by Dr. How, of Windsor:

Metallic copper	19.21
Metallic iron	25.31
Sulphur	22.65
Carbonate of lime	5.15
Oxygen, etc	4.67
Gangue	23.01
	100.00

An analysis of the pyrites from the second vein gave the writer:

Copper	29.00
Iron	29 70
Sulphur	31.50
Silica	3.40
Moisture	.20
Carbonate of iron	6.20
	100.00

"A sample from the third vein gave, at Swansea, 31.25 of metallic copper."

"An assay of seven cwt., at Swansea, gave 19.87 per cent. of copper."* In 1877† forty tons of ore were collected from the pits "and from the level, driven on the three parallel narrow breaks called the fourth vein above. The breaks carry small bunches of solid ore, and were driven on in hopes of striking a main vein. On the brook side, half a mile away, a tunnel driven into the hill cut a small vein, showing copper ore, and a large vein, composed chiefly of spathic iron ore, similar to the vein in which copper pyrites has lately been found in quantity at Polson's Lake."

The copper ore in the Lower Carboniferous rocks of Pomquet Forks is described on page 82 P of this report; that of Knoydart Brook at page 85 P. The latter was mined in 1884 by Mr. Hartley, of New Glasgow, and is said to contain traces of silver and gold. **Pomquet Forks** **Knoydart.**

At Brierly Brook, on the Ohio River, and near Beaver Meadows, the ore found at the contact of the Carboniferous limestone and conglomerate has been mined to a small extent at various times, during the last twenty years, good specimens of yellow and purple copper pyrites being obtained at many points.§ The position of the principal pits is **Briarly Brook and Ohio.**

* Poole, Report of Commr. of Mines for 1876, p. 62.
† Report of Commr. of Mines, p. 48.
§ Geol. Survey Reports for 1876-77, p. 450; and for 1882-83-84, p. 94 H.

marked on the map. Near the head of the Ohio settlement, several openings have been made in the felsites which underlie the Carboniferous limestone. The principal of these is in a finely mottled felsite-breccia, with a broken, softer portion, containing large blotches of broadly crystalline calcspar, mixed with streaks of yellow and gray copper ore, blende and galena. The rock has no regular strike or jointing, but is greatly broken, and the whole of the vein and ore materials may have been infiltrated after the containing rocks were fractured. The ore yields* 1,120 lbs. of copper, 6⅝ dwts. of gold, and 3 oz. of silver to the ton.

Arisaig. Behind and to the westward of Arisaig chapel, and also at the pier, several openings have been made on very small irregular veins, in which specks of iron and copper pyrites and galena were observed.

Garden of Eden. In the mill-brook that crosses the St. Mary's road above Eden Lake, an excavation was made some years ago, about 110 yards above the bridge, in an irregular vein of calcspar, five feet thick, containing specks of copper pyrites. On the east side were soft, shaly, fragmental rocks; on the west, a little pearly mica schist and greenish mixed argillite, perhaps also veinstone. Higher up the brook, are cliffs of fragmental rock, succeeded by greenish soft Middle Cambro-Silurian argillite. Other similar deposits are stated by Mr. Gilpin* to occur in the neighborhood.

Galena—The occurrence in the Carboniferous limestone of specks and crystals of galena, of no economic value, is so common as to attract little attention, although it has sometimes led to the unprofitable expenditure of money in the hope that these traces might lead to richer deposits. "Fragments of *Calamites*, with the tissue infiltrated with galena and iron pyrites, are found on the outcropping of a sandstone bed near Arisaig."‡ Lead ore is said to occur also in Salmon River near Guysborough.||

Arisaig.

Salmon River.

Gold.—The gold mines of the Atlantic coast will be found described in Mr. Faribault's report. Search has been made among the hills, to the northward, for the precious metals, as in Right's River, North River, Bailey's Brook, Georgeville, South River, Malignant Cove and many other places, but without success.

Limestone.—The numerous quarries from which limestone for burning and building has been obtained in the Lower Carboniferous basins

* Gilpin, Report of Commr. of Mines for 1884, p. 23, and for 1885, p. 34.

† Mines of Nova Scotia, page 78.

‡ Poole, Report of Commissioner of Mines for 1873, p. 35.

|| Gesner's Geology, p. 64.

are shown on the map, and many of them, as at Brierly Brook, Dunmore, Ashdale, St. Andrew's. and other places, have been incidentally described in the course of this report (pp. 79 P *et seq.*). The gray limestone of the monastery at Tracadie has been largely quarried for both these purposes. Near Black River it contains veins of white calcspar, with ferruginous streaks and crystals of purple fluorspar. In Limestone Brook, at Fraser's Mills, in contact with red Devonian slates, is a light and dark-gray limestone, of good quality, like that of Blue Cape, which has been quarried for seventy years. Veins of calcspar, spotted with fluorspar, are so numerous as to form a mottled breccia, with which a little conglomerate is sometimes mixed. The limestone follows the brook on the strike in high cliffs and knolls. The dark bluish-gray, strongly bituminous Carboniferous limestone of upper Ohio, can easily be traced along its contact with the felsites. It is covered with soft, rich, black mould, is always greatly fissured, and brooks sometimes run into the fissures and are lost. The blacker portions are broadly crystalline.

Tracadie monastery.

Fluorspar.

Caves.

An analysis of a sample from a bed of limestone, " 15 feet thick, which is extensively quarried at Springville to supply lime for the local demand yielded:—*

East River of Pictou.

Carbonate of lime	96.26
Carbonate of magnesia	2.33
Oxide of manganese	.55
Oxide of iron	.57
Alumina	.10
Sulphur	.02
Phosphoric acid	.03
Silica	1.99
Moisture	.17
	102.02

Gypsum.—The immense beds of white, gray, red and variegated gypsum, associated with the Carboniferous limestone at Antigonish Harbour, and other places, have been already noticed. Formerly it was shipped from Antigonish to other Canadian ports, the shipments in 1877 being 703 tons, but of late years none has been exported.† The compact, white variety, called alabaster, and the transparent pure variety called selenite are abundant.

Alabaster and selenite.

Phosphate of Lime.—The black phosphatic nodules, so abundant in the Silurian rocks of Arisaig, have been described by Mr. Weston‡ but are of no economic value.

Phosphatic nodules.

* Poole, Report of Commissioner of Mines for 1875, p. 69.

† How's Mineralogy, p. 136; Gilpin's Nova Scotia Mines, p. 93; Acadian Geology, p.347; Trans. N. S. Inst. Nat. Sc., Vol. IV., p. 72.

‡ Geol. Survey Report for 1876-77, p. 434.

Salt.—Salt springs and ponds are found everywhere in the neighborhood of the gypsum, as at Pomquet, and South Rivers, Brierly Brook, Addington Forks, and other places. Salt was made many years ago from the salt pond near the town of Antigonish. In May, 1866, a company called the Nova Scotia Salt Works and Exploration Company, was incorporated under the management of Mr. Josiah Deacon, to conduct boring operations to discover the source of the brine.* The first boring was sunk on Town Point, near the mouth of the harbour, a six-inch borehole, lined with iron tubing, being driven through a considerable thickness of soil and clay, then through a thick band of gypsum into sandstones, without finding any indication of brine; so that further operations in this locality were abandoned.

Antigonish.

Encouraged by indications of salt water and salt on the surface, where the railway station now stands, a second borehole was put down here; and a nine-inch cast-iron pipe sunk through sixteen feet of gravel, full of weak surface brine. The auger then passed through red, blue and brown marl, with thin bands of fibrous gypsum; then through several layers of magnesian sandstone, striking a bed of gypsum 141 feet from the surface.

After penetrating 18 feet into the gypsum, there was a flow of pure, strong, limpid brine from a cleft, which flowed nearly to the surface, could only be lowered a few feet by pumping, and discharged a large volume of sulphuretted hydrogen gas. A steam engine was "erected for pumping, and furnaces, tanks and evaporating pans of large dimensions, constructed for the production of salt. After the manufacture of a considerable quantity of salt, the strength of the brine became very much reduced." Another borehole was accordingly put through "clays to a depth of 650 feet, but finding no indications of brine, that of the other boring being too weak for use, and the working capital exhausted, the work was abandoned."

Hallowell Grant.

St. Andrew's.

Sutherland's River.

Mineral Springs.—Mr. Adams' analysis of the water from the spring at Big Marsh, Hallowell Grant is given in the Geol. Survey Report for 1885, page 15 M. Near St. Andrew's, in the neighborhood of outcrops of bluish-gray massive limestone and gypsum, is the "rotten spring," of blackish mineral water, resorted to by rheumatics and other invalids. The water from the brine spring in Sutherland's River, above Parks mills,† is also highly esteemed for a variety of diseases.

Tracadie.

Clays, fit for the manufacture of bricks, occur at many localities. At the Tracadie monastery, bricks of good quality have been made for local

* Gesner's Geology, page 92; How's Mineralogy of Nova Scotia, p. 145; Trans. Nat. Sc., Vol. IV., p. 74; Acadian Geology, p. 350; Report of Commissioner of Mines for 1874, p. 58.

† How's Mineralogy, p. 144.

use. Several brick-yards are in active operation near Antigonish, and also about three miles from the town on the Sherbrooke post road, and in the intervale of West River. On the right bank of South River, a short distance above McEachern's bridge, near St. Andrew's, is a large quantity of rusty-white clay, which would make good bricks. Higher up South River in a small brook from the eastward at Cummings' bridge, a red, oily, fine clay is used for paint; and higher still, a white similar paint-clay. Antigonish. Paint.

On the road between the Avondale post-office and school, about 150 yards west of the main road, is a seam of bright-red, heavy clay, resembling putty, used for paint; and a short distance northward, a thin band of tough, blue clay. The brick-clay of the Middle River of Pictou has already been mentioned. Avondale. Middle River.

The annual make of brick in Nova Scotia was estimated by Mr. Gilpin, at 10,000,000 for 1879; and the selling price in Halifax at $8.00 per 1000. In 1850, How gives 2,845,000, and in 1860, 7,659,000, as the annual production. Pictou coal-field.

Fireclay.—" 40,000 bricks were made in 1879,* from a bed of fire-clay, four feet thick, overlying the McGregor seam. The clay was considered by Mr. Jamme, at that time manager of the Londonderry iron mines, to be the best plastic clay he had ever used for lining blast and puddling furnaces. " According to Mr. Haliburton, the clays of this district have been pronounced by parties in Staffordshire unsurpassed by any in England."†

Building Stones.—The use of the various bands of Carboniferous limestone and sandstone and of Permian sandstone for building purposes, has been before referred to. Some of the sandstones of the West River of St. Mary's, below Wallace bridge, are suitable for flags and grindstones. St. Mary's.

In the Monastery Brook, Tracadie, a flaggy micaceous, Lower Carboniferous sandstone has been quarried for local use; and near Monk's Head and other localities, rough building stone has also been obtained from the same formation. A gray sandstone, quarried at Heatherton, was used principally in the construction of railway culverts and bridges. In certain localities, as at Ogden Brook, the rough gray sandstone, associated with Carboniferous conglomerate has also been quarried for local use. In Barney's and French Rivers, freestone and grindstone have been obtained from the Millstone Grit. But by far the largest part of the stone exported comes from the quarries between Pictou Harbour and Big Island, Merigomish. The yield from these quarries in 1877, was 1500 tons, valued at $7,500. In 1885, Antigonish exported thirty-six tons of building-stone, valued at $144. Tracadie. Heatherton. Barney's and French Rivers. Pictou Harbour Merigomish and Antigonish

* Report of Commissioner of Mines, p. 15.
† How's Mineralogy, p. 167.

Grindstones.—In addition to excellent building stone, the quarries last mentioned furnish a large quantity of grindstones. The yield of the Merigomish quarries in 1877 was 382 tons, valued at $4,764. They are nearly all situated in the Permian area, and the principal quarries, already described, are on Pictou Harbour, McKenzie Point, Roaring Bull Point, Quarry Island, Big and Roy Islands. Many interesting particulars concerning these quarries are given in the catalogue of the Indian and Colonial Exhibition, and also in the report by Mr. Coste on the Mining Industries of the Dominion, Part S.

Merigomish.

Scythe-stones.—On the point of Big Island west of Smashem Head, a reddish, hard, shaly sandstone has been locally used for sharpening scythes and for other similar purposes, for which it is said to be well adapted.

South River.

Marble.—The crystalline limestone of Hattie's millstream on the west side of South River Lake, may be from a large, homogeneous vein. It is white, finely crystalline, pure and good, like the finer varieties of Marble Mountain and George River.* The mixed, impure crystalline limestone of Livingstone Brook, is probably a vein. The large mass of the shore at Georgeville is described on page 8 P.

Georgeville.

East River of Pictou.

Fraser's Mountain.

Professor How† describes a greenish colored marble from the East River of Pictou, and a gray, patterned, concretionary variety from Fraser's Mountain, which exhibits in a polished specimen "concentric waved bands in separate sets whose outlines somewhat resemble expanded flowers, . . . it would make fine inlaid work." The quantity is said to be considerable, but not all equally beautiful. The so-called marble worked on Brown's Mountain, is a gray and reddish, pink-weathering grit and syenite, jointed and full of quartz-veins.

Brown's Mountain.

Syenite, Porphyry, etc.—Many varieties of these rocks fit for ornamental work have been met with, but none utilized.

Barytes.—This mineral is frequently found in association with veins of calcspar in Carboniferous limestone, as at Hallowell Grant; it is‡ mixed with red oxide of iron at Frenchman's Barn, and accompanies the iron ores of the East River of Pictou, in small tabular plates.§

Graphite.—Several pits have been sunk on Salmon River, above the Tor Bay road near Guysborough, in a black shale, probably Devonian, and near the contact of the gold-bearing series, which contains a considerable quantity of graphite.

* Geol. Survey Reports for 1875-76, p. 382: for 1876-77, p. 456: and for 1877-78, p. 30 F.
† Mineralogy of Nova Scotia, p. 158.
‡ Trans. N. S. Inst. Nat. Sc. Vol. III., p. 233; How's Mineralogy, p. 161.
§ Gesner's Mineralogy, page 63.

Infusorial Earth.—"Many of the lakes of Nova Scotia contain large deposits abounding in remains which consist of the siliceous skeletons of upwards of sixty species of diatomaceae, and of the siliceous spicules of at least seven species of fresh-water sponges. The deposits from different lakes are generally marked by a difference in the species present or in their relative proportion. In lakes which are not agitated by large streams bearing earthy sediments during times of freshets, the deposits consist generally of a light slimy brownish mud, sometimes of a depth beyond twenty feet, into which a pole can be easily driven by the hand. This mud, when treated so as to eliminate the carbonaceous vegetable matter, leaves a variable percentage of exquisitely sculptured diatom cells and various forms of sponge spicules. In some places, this percentage is very high and the deposit correspondingly whiter and firmer, in some cases consisting nearly of the pure siliceous valves and spicules. The diatomaceae grow not only in the waters of these lakes but in the streams flowing into them, so that these deposits are not all developed *in situ*. The sponges, on the other hand, affect the stiller waters of the lake. They attach themselves to and grow upon portions of submerged wood or stone, or even on sand, sometimes forming extensive incrustations several inches in thickness, some species extensively lobed and even branching. The sponge-flesh, dying away each winter, innumerable microscopic spicula, which formed its skeleton, are thus scattered in the waters, so that in some localities, the sponge spicules form a greater proportion of the deposits than the valves of the diatomaceæ."

"Some of these deposits may prove to be of industrial importance, the material being regarded as capable of use as polishing powder for various purposes, and in the manufacture of dynamite."* **Industrial uses.**

The lakes mentioned by Mr. McKay as containing these deposits are: Ainslie in Cape Breton; Lochaber in Antigonish; Mackay, Black Brook, Eden, Grant, McLean, Calder, Forbes, Ben and Toney Lakes in Pictou County; Mackintosh, Earltown and Gulley Lakes in Colchester; the lakes which supply the city of Halifax with water, Grand and Dartmouth Lakes in Halifax county, and Kempt Lake in King's county. **Localities.**

About four tons of this material were shipped in 1886, from a small deposit in a marsh at Alexander Sutherland's (Sergeant), Upper Barney's River. The extent of the deposit is not known; the marsh is fifty yards wide, of indefinite length; the layer of infusorial earth two feet thick immediately under the sod. **Barney's River.**

At Englishtown, St. Ann's, Cape Breton, a deposit of this earth, said to be of excellent quality, has been somewhat largely dug, by Mr. J. Fraser Torrance, from a small lake behind the village. **Cape Breton.**

* Principal A. H. McKay in the Report of the British Association for 1884, p. 742.

Sand.—Good sand is found on many of the sea beaches and among the drift. A considerable quantity of fine sand from the beach of Roy Island has been used at Acadia coal mines. North of Avondale post-office, a deposit of sand, said to be suitable for moulding, is found close to the road to Bailey's Brook. It is also abundant on the East River of Pictou,* the best known deposit being near the mouth of McLellan's Brook. In 1876 Antigonish sent 227 tons of sand, valued at $1 a ton, to Prince Edward Island.†

Roy Island.

Avondale.

East River of Pictou.

Slate.—On the north branch of Guysborough River, above the Afton road, is a quarry of dark bluish-gray Devonian argillite, evenly bedded but having also an oblique imperfect slaty cleavage. The shales do not always break out smoothly, and the adherence of the different layers to one another is very strong. In Shaw's and Aikens Brooks, similar slates have been quarried, but no satisfactory roofing slate seems to have been discovered.

Guysborough River.

Pencil Stone.—Clay-slate, useful for making slate pencils, is found in abundance, according to Dr. Honeyman, among the Silurian and Cambro-Silurian soft argillites of Antigonish and Pictou counties.

Dysyntribite.—Associated with the felsites of Frenchman's Barn and Arisaig pier, is a soft unctuous rock, of yellow, orange, red, green, gray and other finely mottled colors, belonging to the agalmatolite, parophite and dysyntribite group of minerals,‡ said by Dr. Honeyman to be twelve feet thick, traceable for a great distance, but passing on the strike from a massive rock into slates. It is susceptible of a high polish, but broken by cleavage joints, and tarnishes easily; has been quarried to some extent as an ornamental stone, and might also probably be used for anti-friction purposes and pottery making.

Arisaig.

Garnet.—Dr. Honeyman mentions § garnets as occurring at Polson's Lake. Crystals of quartz, of great beauty, are often found in veins among the Devonian slates.

Rock crystal.

* Trans. N. S. Inst. Nat. Sc., Vol IV., p. 145.
† Report of Commissioner of Mines for 1876, p. 64.
‡ Geol. of Can., 1863, p. 484; Trans. N. S. Inst. Nat. Sc., Vol. III., p. 288, and Vol. VI., p. 320.
§ Trans. N. S. Inst. Nat. Sc., Vol. I., p. 110.

REPORT

ON THE

LOWER CAMBRIAN ROCKS

OF

GUYSBOROUGH AND HALIFAX COUNTIES,

NOVA SCOTIA.

By E. R. FARIBAULT, C.E.

INTRODUCTION.

This report, and the maps which accompany it, comprise the result of investigations made, since the fall of 1882, among the gold-bearing rocks of the Atlantic coast of Nova Scotia, in southern Guysborough and eastern Halifax counties.

Acknowledgments.

I wish to offer my thanks to the many persons to whom we are indebted for services rendered in the performance of this work, and more especially to the following: Thos. Millward, of Stormont; K. S. Sweet and J. L. Smith, of Country Harbour Cross-roads; Thos. O'Neil, of Salmon River Lake; J. C. Flick, of Holland's Harbour; Dr. A. F. Falconer, James McDaniel, Thos. Campbell, Jas. H. McDonald and Alex. McDonald, of Sherbrooke; James A. Fraser, M.P.P., Alex. McDonald and John Williams, of Goldenville; H. Elliott and Alex. McDonald, of Stillwater; Alex. McKenzie, C.E., and J. Stewart, of Melrose; W. T. Smith, R. Findlay and A. Chisholm, of Caledonia; John Nelson, of Trafalgar; J. Hemloe, of Little Liscomb; Thos. Creighton, of Liscomb Mill; John Malay, of Ecum Secum; John Fraser and McMann Brothers, of Moser's River; E. Malayo and Ed. Archibald, of Salmon River Mine; Jas. McG. Cruikshank and J. F. McKenzie, of East Sheet Harbour; J. A. McDaniel, of Sunnybrae; Henry McLean, of Hopewell; W. J. Chisholm, Edwin Gilpin and James H. Austen, of Halifax; F. N. Gisborne, Ottawa.

Character of the country.

The whole of the country under consideration is low, the hills seldom rising more than five hundred feet above the level of the sea.

The granite hill east of Donahue Lake, 725 feet high, and the Bull-ridge east of Stillwater, are the most prominent elevations of the district. A decided and uninterrupted ridge follows the northern boundary of these rocks from Cape Canso to Trafalgar and beyond, indicating the axis of the principal granite masses. The rivers and larger streams of the district taking their rise from this ridge, flow southward into the Atlantic.

The Country Harbour and St. Mary's Rivers, however, rise further north in the Devonian formation, and intersect the ridge at right angles in gorges with high, steep sides. The valleys of the other large streams are also often deep and narrow, and present very little intervale; the rocks being hard and compact, produce only light soils, but are remarkable for the numerous lakes, ponds, lagoons, still-waters and swamps upon them. More than five hundred lakes have been surveyed.

Forests.

Extensive fires, at different times, have destroyed the forests along the shore, and in many places to a great distance inland, increasing the original barrenness of the surface. Large dense forests, affording good ship-timber, are still to be found on the headwaters of the rivers of New Harbour, Isaac's Harbour, Indian Harbour, Liscomb, Ecum Secum, Moser's, Quaddy, Salmon and Sheet Harbour, and lumbering is still carried on extensively on those of Sheet Harbour, Moser's and Liscomb.

Except in the St. Mary's and Country Harbour valleys, the interior of the country is uninhabited, being for the most part unsuitable for agriculture; and along the shore most of the inhabitants are engaged in fishing.

Cultivable land

Fine tracts of woodland, fit for agriculture, occur, however, on Moser's, Ecum Secum and Indian Harbour Rivers, where the detritus of the black slates, which attain here their greatest width, yields a deeper and more productive soil than the granite and quartzite.

Harbours.

The sea-shore is intersected by numerous deep, narrow harbours, bays, coves and creeks, which afford good shelter for fishing vessels.

The principal harbours of refuge for large vessels are Whitehaven, Country, St. Mary's River, Liscomb, Mary-Joseph, Beaver and Sheet; of these, Whitehaven* and Liscomb, together with Halifax, are regarded as the best harbours along the Atlantic coast of Nova Scotia, being never obstructed by drift ice.

* Haliburton's History of Nova Scotia, Vol. I., p. 103.

Area of the Gold-Bearing Rocks.

The gold-bearing rocks of Nova Scotia cover nearly one-half the superficies of the province, that is, according to various authorities, from 6000 to 7000 square miles.* Of this area, which stretches along the Atlantic coast from Canso to Yarmouth, rocks supposed to be of Lower Cambrian age occupy about one-half, and granite the remainder. The eastern part only, as far as Sheet Harbour, has been surveyed and mapped, and is here reported upon. Chedabucto Bay forms the northern boundary to the mouth of Salmon River, where it leaves the shore, and keeps immediately south of the river as far as Ogden, thence along the old Bantry road to the outlet of Hurley Lake, beyond which it runs in a southerly course, striking Country Harbour River one mile and a quarter below the Cross-roads. From this point, the line runs a few degrees north of west to Trafalgar, keeping south of the Country Harbour road, Melrose and the West River of St. Mary's. On the south, these rocks extend to the Atlantic Ocean, and form the numerous outlying rocks, reefs and islands so dangerous to navigation on this coast.

Extent.

Classification of the Rocks.

The rocks in the region described in this report, may be classed as follows:—

Gr. Granite (porphyritic and gneissic.)

C. Lower Cambrian, { Lower or quartzite group, Upper or graphitic and ferruginous slate group.

Gr.—Granite.

Masses and dykes of granite intersect the Lower Cambrian strata in many places from Cape Canso to St. Mary's River, and also immediately

* In the Geological Survey Report for 1870-71, page 268, the area of the gold-bearing rocks of the Atlantic coast of Nova Scotia was described by me as follows:—

"The extent of the Atlantic coast series of stratified gold bearing slate and quartzite, has been variously estimated at from 5,000 to 7,000 square miles. My observations during the past summer induce me to think that this estimate is very considerably too large. The mistake has probably arisen from defective information respecting the area occupied by the granitic rocks; which, as I have already pointed out, is very largely in excess of that assigned to it on published geological maps, from which the computations referred to have probably been made. The area represented on Sir W. E. Logan's large map of Canada as occupied by strata of Lower Silurian age on the Atlantic sea-board of Nova Scotia is about 5,400 square miles, and of this probably fully more than 1,400 square miles are occupied by granitoid rocks. Exclusive of Cape Breton Island, 3,500 square miles would, therefore, probably represent the total extent of the area over which the stratified slaty and quartzose auriferous rocks are distributed."

This closely corresponds with the estimate now given by Mr. Faribault.—Alfred R. C. Selwyn.

Superficial extent.

south of the West River of St. Mary's, from Cochran's Hill to Trafalgar, occupying approximately 235 square miles, or about one-fifth of the whole area examined. The granite constitutes a prominent ridge marking the line of greatest disturbance of the district. It occurs in five separate and distinct areas. The first extends from Cape Canso to Whitehaven, the second from Cole Harbour River to New Harbour River, the third from Ogden to Sherbrooke, the fourth from Cochran's Hill to the Cameron Settlement, and the fifth from the Cameron Settlement to beyond Trafalgar. Within each area there are several masses and dykes of granite, which will be referred to further on.

Subdivisions.

Characters of the granite.

The granite varies very much in composition and texture, according to its position, whether in the large masses or in more or less close proximity to the surrounding sedimentary rocks. In the large masses, it is generally whitish or reddish, composed of white or pink felspar, white, colourless or smoky quartz, and white silvery mica, all uniformly distributed in a fine and compact or crystalline admixture. In the centre of these masses, the rock often assumes a porphyritic structure forming a beautiful light-gray granite, with a finely crystalline paste of uniform texture, containing large, scattered crystals of felspar, averaging half an inch, but often attaining one inch and a half in length, uniformly distributed through the mass. Very good exposures of this granite may be seen on the road between Crow Harbour and Cole Harbour, also one mile up the Basin and Eastern Brooks between Tor Bay and New Harbour, in the southern part of the granite mass east of Sherbrooke, and south of Trafalgar on the south branch of the West River of St. Mary's.

Exposures.

Schist.

At the edges of large masses, the granite is found frequently to pass gradually into a foliated schistose rock, which, losing its crystalline texture, itself passes insensibly into the altered sedimentary rocks. This alteration is shown to great advantage at a twelve-feet fall on the Patterson brook of New Harbour River, and at the Glenelg bridge, on the East River of St. Mary's.

Dykes.

Dykes and veins of granite are often seen cutting Lower Cambrian strata in the vicinity of the large masses, but also in many instances far from such masses. They are generally of a very coarse and irregular texture, the felspar and quartz often attaining two feet in diameter, while the mica is in large scales, forming perfect hexagonal crystals.

Such dykes cross the Whitehaven road a quarter of a mile south of its junction with the Canso road, and are also seen in a barren, half a mile south-west of Desert Lake.

The small veins, on the contrary, are generally finely crystalline; as they thin out, the mica and even the felspar disappears gradually and they become simple quartz veins. Veins.

Good examples of such quartz veins are to be seen at the dyke crossing the Whitehaven road, at Cochran's Hill, a little distance south of the Crow's Nest gold mine, and also a few hundred yards up Churn Brook and the Mitchell mill-brook of the West River of St. Mary's.

Description of the Granite Areas.

1. *Cape Canso Granite Area.*—The most easterly of the five areas is occupied by three distinct masses, with dykes and veins, generally following the strike of the surrounding altered rocks, but also intersecting them so promiscuously as to form a network of veins, which often extend from one mass to another.

The most northerly of these masses may be described in some detail, for it is nearly all covered by barrens where the denuded rocks are well displayed, and is crossed by roads which make every part easily accessible. It does not exceed a mile and a half in width, and stretches from the Cranberry Islands in a westerly direction for twelve miles, taking in the southern part of Georges, Piscatiqui and Durell Islands and Canso, whence it follows Chedabucto Bay to one mile west of Fogherty Point. Lazy, Black, Fogherty and a few other points are, however, occupied by altered Lower Cambrian rocks, and no granite is seen at Fox Bay for a distance of three-quarters of a mile, where Indian Cove has, apparently, been cut out through an otherwise continuous mass of coarse whitish or reddish-grey granite. This variety also constitutes the dykes and veins so numerous at the contact of the main granite masses with the stratified rocks, and is again found on the old shore road to Canso, east of Tor Bay, penetrated by numerous patches and veins of quartz. First mass. Canso.

On the Canso road, between Wilkins Lake and Three-mile Lake, and both west and south of the latter, coarse gray granite traversed in every direction by veins of white, smoky and gray quartz, varying in thickness from eight feet down to a few inches, is mixed with altered gneissic and quartzo-felspathic rocks. The outer part is largely composed of a coarse gneissic variety which in many places gives good examples of the gradual passage of granite into gneiss. Quartz-veins.

On Reynolds Brook, above the Canso road, at the contact east of a small pond, the quartzo-felspathic rock is crystalline, even at a distance of two hundred yards from its junction with the granite; and the degree of crystallization is but slightly increased till within a few feet of the contact where the coarse gneiss is distinguishable from the granite

Gneiss running into granite.

only by its foliated, undulating structure. This contact is everywhere very irregular and presents no clear line of demarcation, the foliation insensibly dying away, and small patches and tongues of granite running, generally in an easterly and westerly direction, in the surrounding quartzo-felspathic rocks. The gradation, indeed, is so regular that it appears as if, during the process of folding, the component minerals of the Lower Cambrian strata had been, under enormous pressure, and owing to the presence of water or vapors, fused and mixed with those of the plastic granitic magma squeezed into the crevices. At the contact observed on Long Lake north of Hazel Hill post-office, and at that on Wilkins Lake south of the Canso road, the granite is also associated with gneissic granite, perhaps in larger quantity than on Reynolds Brook.

Along the shore of Fox Bay, west of Indian Cove and along the south side of Tickle Channel, numerous dykes and veins of granite, sometimes foliated, associated with quartz patches, and often of a dark red colour, pass from the main mass into the quartzites and black slates which do not appear to have been more altered at the immediate contact than they usually are in this district at some distance from it.

An isolated dyke crosses the Whitehaven road, half a mile south of its junction with the Canso road, and extends for at least one mile and a half: it is mostly composed of reddish-gray very coarse granite or pegmatite, having many veins and blotches of white quartz, often very irregular but generally running like the dyke in an easterly and westerly direction. Passing from the dyke into the surrounding country-rock are many small veins of granite which likewise follow its strike, and in thinning out, often lose their mica and felspar and become quartz-veins. In the mine worked by Mr. John Pillsbury in the rear of John Reynolds' at the eastern end of this dyke, quartz-veins of this character are cut through, which pass into coarse granite and carry iron pyrites, yellow and horse-flesh copper ore, mispickel and a greenish clay.

Mine on the Canso road.

The two other masses in this first area lie more to the south on the Atlantic coast. The smaller does not exceed two miles in width and five miles in length; it extends from the North-West Arm of Whitehaven eastward along the north side of the North-East Arm to the Dover, Young and Wilkins Lakes of Dover Bay. The other mass, and by far the largest of the three, extends from Cape Canso Island along the Atlantic coast to the Flying Point of Whitehaven, a distance of fifteen miles, varying in width between three and six miles, including the numerous islands on this shore and running north as far as Glasgow Harbour, Hazel Lake, McKenzie Brook, the head of Dover Bay and Marshall Cove.

Second mass.

Third mass.

Many narrow belts, dykes and veins of granite are associated with the rocks between the two granite masses, sometimes connecting them: these are difficult to trace in detail, and those marked on the map as crossing Wilkins, Charles, Young and Dover Lakes, and the North-East Arm, are, therefore, indefinite; but it will be seen that they have, as usual, the tendency to follow the strike of the stratified rocks, although in many places they are also much intermixed with them.

On the north side of the North-East Arm, a contact between slate and granite was observed, the latter being fine-grained and in places almost a pure quartzite, but succeeded by the common light-gray granite of the country which extends as far as the North-West Arm. The slate for two inches from the junction is converted into a granitoid rock composed almost wholly of crystals of andalusite; at three inches the rock might properly be called a fine mica-schist, beyond which the strata are concealed. **Whitehaven.**

In the country between Dover Bay and Whitehaven are found many small lenticular patches of gneiss, running east and west, or north-east and south-west, parallel to the strike of the quartzite and slate further north; this would seem to prove that the gneiss was foliated at the same time that the latter were folded. **Period of foliation.**

The granite country between Cape Canso and Whitehaven is all barren, and the rock more exposed than in any other part of the district. Huge erratic blocks of granite are found on the polished surfaces of the highest elevations, while the depressions are filled with smaller, angular blocks, which give the country a rough and rugged appearance.

2. *Tor Bay Granite Area.*—Further west is a second area, which differs from the first in that besides the ordinary light-gray or reddish-gray variety, it contains a large quantity of porphyritic granite. It lies north-west of Tor Bay, extends twenty miles west to New Harbour River, and is occupied by three separate masses of granite. **Porphyritic granite.**

The easternmost extends from a quarter to one mile north of the shore of Tor Bay to within half a mile of Crow Harbour, and from Cole Harbour River to Halfway Cove Lakes. **First mass.**

A very interesting contact of gneiss and granite was observed on the edge of this mass, half a mile south of Lamb's Point, west of Crow Harbour. The two rocks are mixed along the contact through a width of more than a hundred yards, layers of gneiss striking east and west in the granite, which holds also wedges of gneiss, sometimes six feet long and nine inches wide. At one place, granite dykes cross the bedding of the gneiss, which is of comparatively fine texture, full of mica, and contains lenticular veins of clear vitreous quartz, on the **Crow Harbour.** **Quartz veins.**

Staurolite.

surface of which are fine crystals of black hornblende and compound crystals of staurolite. A small belt of granite, twelve feet wide, runs in the bedding of the gneiss N. 58° W.; and in a direction parallel to the main belt, and near its edge, there are small connecting tongues and lenticular veins often passing into quartz.

Granite dykes passing into quartz.

A spur, running from the main mass to the eastward for three-quarters of a mile, crosses the north-east branch of Larry's River, about half a mile above the fork. It does not exceed a quarter of a mile in width, and is entirely composed of coarse gneissic granite, roughly foliated, and altering the neighbouring mica-schist and slate. On the eastern shore of Crow Harbour, a dyke of reddish fine granite, with obscure lines of stratification and foliation, runs in the bedding of the laminated whin or quartzite, which here occupies the shore. This dyke is probably connected with the first granite mass, although over a mile distant from it.

Second mass.

The second mass of the Tor Bay area, to the west of the first, is bounded on the south by the Halfway Cove, Bonnet and Donahue Lakes, and extends north to Chedabucto Bay, where it is exposed along the shore from Halfway Cove westward for one mile and a quarter. It presents at its western end the most prominent elevation of the district, and rises east of Donahue Lake about 725 feet above the level of the sea. The shore of Chedabucto Bay is very rough, rocky and indented for the first three-quarters of a mile west of Halfway Cove, and, as well as the Canso road, which is close by, consists of granite, often coarse.

Halfway Cove.

Further west, in different places on the shore, the granite, which is sometimes reddish-gray, breaks through altered slates or felsites, which in one place appear to underlie it, and are altered into compact, dark bluish-gray felspathic rocks, like the Coxheath * laminated felsites.

A little distance further is an obscure granite, blotched with quartz and epidote, in the midst of greenish-gray compact rocks, closely followed by very coherent felsite, obscurely gneissic, like the rocks of Capelin Cove,† and apparently sedimentary. A quarter of a mile up Halfway Cove Brook, the mica-schists dip N. 46° W. off a face of gray granite, which follows the brook, and is also well exposed 700 yards further west, where it crosses a small tributary, and cuts off the slate. Up this brook, there is a beautiful white variety of granite, of uniform compact texture, composed of grains somewhat smaller than peas.

Donahue Lake.

Donahue Lake, one of the largest lakes of the district, is only half a mile wide, but over three miles long, studded with several small

* Geol. Survey Report for 1875-76, p. 373.

† Geol. Survey Report for 1877-78, p. 9 F.

islands, and full of fine trout. The eastern side, with its rough white granite cliffs, contrasts strongly with the beautiful deep-green hardwoods bordering its low, undulating western shore. The granite barrens between this lake and the Sandy Cove Lakes display rocky surfaces, without a trace of vegetation, upon which large rectangular slabs of granite, detached from the solid mass, lie conspicuously around. At one place, long, parallel white bands, from one inch down, and one to three feet apart, composed essentially of crystalline felspar, run N. 54° W. in the granite, and are traceable for twenty-five yards along the strike. At the northern end of Donahue Lake, mica-schist and slate are seen to dip south-east against the granite at an angle varying between 70° and 70°. Scenery. Barrens.

North-west of this mass, along the shore from Sandy Cove westward, and up the south side of Salmon River, beyond the bridge on the Tor Bay road, are several narrow belts and dykes of obscure granite, intermixed with slate and quartzite. The granite varies much in composition and texture, and differs from that of all the other masses of this district. Sandy Cove. Salmon River.

On the shore, half a mile east of Sandy Cove, gray and whitish-gray granite lies in lenticular masses in the bedding of the quartzite, and encloses also blocks of it, having, apparently, like the quartz-veins, being formed along the lines of least resistance in the strata. In places, indeed, the two are associated, and one belt of granite, about a foot wide, contains an inch of quartz on each side. Some seventy yards further east, are curious vein-like masses of granite, precisely like quartz-veins, and giving the impression that they have originated in the same way. The strong probability is that some of these at least have never been connected with any large mass. A few yards further east, a granite vein is replaced or continued by one of quartz, which again on its strike contains patches of granite. These bands are never more than three or four feet wide, but appear to continue westward, crossing the Canso road a quarter of a mile east of Sandy Cove Brook, and ending within a quarter of a mile of Delaney Brook, and at the same distance south of the road. The granite is here rather a compact quartz-felsite, with a porous, quartzose, weathered surface, like pumicestone; sometimes, apparently, a breccia and full of epidote. Granite vein.

Similar rocks on the shore at the mouth of Delaney Brook belong to a belt which, running westward, crosses Hyde Brook just above the road and thence follows the south bank of Salmon River to a mile and a half or more above the Tor Bay road.

On Hyde Brook, the rocks are rusty-weathering, pyritous, dirty granite, the constituents of which are not well mixed, and fine-grained, dark diorite. This belt averages a quarter of a mile in width, Diorite.

and forms part of the escarpment of the northern boundary of Lower Cambrian rocks.

Third mass. Tor Bay and New Harbour.

The third mass lies immediately south of the last and extends from near Gamman Basin westward along the eastern side of New Harbour River to half a mile above the Third Fork, having a length of twelve miles with a breadth of five. Its country is broken, rocky and barren, and often rendered almost impenetrable by wind-fall, intermixed with scrubby, second-growth black spruce. The northern boundary leaves the Tor Bay road opposite Square Lake, running westward and crossing the New Harbour road one mile south of the Junction,and Loon Lake Brook, three-quarters of a mile south of Loon Lake. Besides the ordinary light gray and reddish granite, the porphyritic variety is found in many places, especially up the Eastern Brook of New Harbour, where specimens show large crystals of felspar, beautifully scattered through the mass. An irregular bolt of Lower Cambrian rocks, little more than a quarter of a mile wide, runs up Patterson Brook, in the very midst of this granite mass, as far as Canter and Sangster Lakes, a distance of over three miles. The rocks of this belt strike east and west; they are evidently cut by the granite and greatly altered. From the western end also, long dykes run westward and cross New Harbour River above the First and Third Forks. One of these dykes crosses the brook from Ocean Lake half a mile below the outlet, in a direction parallel to the strike of the associated quartzites.

Dykes.

The granite is here very fine and hornblendic. Other dykes cross the eastern branch of the Third Fork a quarter and half a mile further up. One of them, of gray granite, two feet wide, runs in the bedding of greatly altered slate which is full of staurolite crystals near the contact, and cut by many irregular veins of quartz.

Extent.

3. *Country Harbour Granite Area.*—This area is some three miles west of the last and extends from Ogden to Sherbrooke, a distance of twenty-two miles. It is occupied by five separate principal masses and a few smaller ones.

Five masses.

First mass.

Ogden.

The first, and by far the largest, has a surface of thirty-four square miles, and is about twelve miles long. On the north side it is in contact with the Lower Devonian for two miles, from Ogden north-westward along the Guysborough road. Leaving the Lower Devonian, the granite is overlain by the Carboniferous, the contact running south-west along the old Bantry road to within a mile of Country Harbour Cross Roads. A narrow band of whin is left, however, between the granite and the Carboniferous south of Hurley Lake, for a distance of three miles. The southern boundary along the Lower Cambrian rocks is very irregular, coming near the Country Harbour road at the lower

bridge on the river, and also further down at Johnson Brook, where it adjoins the Country Harbour gold-district; while in other places it is over a mile and a half from the road. The line of contact further east crosses Howlett's Brook one mile up the stream, the headwaters of Stewart Mill-brook three-quarters of a mile above the lake, and thence runs to the foot of the Big Still-water. At the east end, the mass divides into two prongs separated by a tongue of Lower Cambrian rocks, one mile and a half wide, running westward between them for some six miles.

Country Harbour gold-district.

On the line of contact in Lawlor's Brook, one hundred yards above the mill-dam, irregular dykes of light-gray fine granite break across the bedding, but also run parallel with it for many yards. The associated rocks are much altered, but the lines of contact are quite definite, and there is, apparently, no passage of one into the other as was observed in some parts of the masses to the eastward. About two hundred yards further up, the prevailing granite is white, with streaks of a fine red variety, chiefly composed of compact crystalline quartz and felspar, with a few large spots of mica. This red granite appears to form a large part of the eastern end of this mass. It was observed on the Salmon River road at a small brook near the Ogden schoolhouse, where it passes into a beautiful deep-red, finely crystalline quartz-felsite or syenite; and also, one mile and a quarter further west, at a ten-feet fall of a small brook, south of the old Bantry road.

Red granite.

Foliated, coarse gneissic granite appears to occupy much of the country west and north of the Big Still-water of Isaac's Harbour River. It was seen up a small brook a few hundred yards west, at the line of contact a quarter of a mile up the east branch, and half a mile up the west branch. On the headwaters of the east branch of Stewart Mill-brook, numerous blocks of gneiss are found with huge blocks of granite; and there may possibly be small isolated patches of gneiss *in situ*, in the vicinity, although the blocks may have been drifted from further north. In some of these blocks, the plates of mica are one inch square, the crystals of felspar much larger, while the quartz is in masses or veins several feet wide. It is near the quartz veins that the coarse aggregations always seem to occur.

Isaac's Harbour River.

A quarter of a mile south of this mass of granite is another, stretching eastward in a narrow belt from the Country Harbour road opposite Green Point for about four miles to beyond Stewart's. At the head of the third small brook below Howlett's Brook, a dyke of gray granite, nine inches wide and apparently connected with this mass which is close by, was observed running east and west in the bedding of altered whin or fine gneissic rock, from which it is clearly distinct, there being no passage of one into the other. A little to the south of this last mass

Second mass.

Country Harbour Narrows.

are two others of small extent: one of these only a few hundred yards wide, crosses the brook a quarter of a mile below the schoolhouse; the other, three-quarters of a mile further down; both are of a gray, massive granite.

Third mass. The three other granite masses belonging to this third area are found between the Country Harbour and St. Mary's Rivers. The most northerly, only three-quarters of a mile wide, and two miles long, extends from the vicinity of the shore and opposite the Narrows, westward to the head of the south branch of the West Brook of Country Harbour River. The granite, generally coarse, contains large masses and veins of white quartz. An exposure of gray granite, apparently of small extent, was seen on Hudson Brook, half a mile north of this mass.

Fourth mass. The fourth mass is narrow, lenticular and irregular, over nine miles long, stretching from the Country Harbour River, about two miles below Fenton's Brook, as far as the north side of Lake Brûlé, where it attains a width of one mile, and then branches off. One branch, running a little north of west, takes in the upper part of Head Lake of Indian River, and narrows, two miles further west, into a dyke not over forty yards wide, composed of pegmatite, the component minerals of which are very irregularly mixed and coarse; the quartz and felspar in places often exceeding the size of a man's head, while the mica is in scales over six inches in diameter. This dyke projects conspicuously above the level surface of the barren, and is capped by light-gray gneiss, in layers between three and six inches thick, alternately composed of crystalline quartzite and quartz-felsite and fine gneissic granite, evidently the "whin" rocks altered and upheaved by the granite. One mile north of this dyke are auriferous measures which were worked to some extent several years ago, but are now wholly abandoned.

Conspicuous dykes capped by gneiss.

Old Country Harbour gold-mines.

The other prong runs from Lake Brûlé, a little south of west, and after crossing Indian River about a mile below the Head Lake, widens out to one mile and a quarter at the Bull-ridge, and extends along the north side of Archibald Lake and a little beyond.

Fenton's Brook The eastern end of this mass consists principally of several dykes of light-gray fine granite which run along the shore of Country Harbour as far as Fenton's Brook. The contact on this brook is one of the most interesting in the district. Granite, gneissic granite, fine gneiss, andalusite pyritous slate, with numerous quartz masses and veins in succession cross the brook, and are closely associated and intermixed, the granite occurring either along or across the bedding.

The barren at the head of Fenton's Brook is in places paved with granite, out of which the other constituents have weathered, leaving the quartz on the surface, whence it can be taken in handfuls. The

Bull-ridge, a high, bare escarpment of whitish coarse granite, running east and west, overlooks the surrounding country. Seen from its summit, the barren extending southward to the Atlantic coast, presents a most dreary and desolate view. Bull-ridge.

A few dykes occur also further south, along the west side of Country Harbour.

A four-inch vein of granite crosses Armstrong Brook, below the hay-marshes at its head; and, judging from the number of blocks of granite met with a great part of the way downstream, it is probable that other masses cross the brook. Reddish-gray coarse granite, with black mica and flesh-colored felspar, runs along the bedding of highly altered and tilted rocks for about half a mile on the shore of Country Harbour immediately south of Armstrong Brook. At the northern end of Mount Misery, a narrow dyke of reddish-gray granite with very little silvery mica, runs in a southerly direction and slightly across the bedding of highly metamorphosed rocks; it appears to be a prolongation of the last-mentioned small mass. It is of uniform width, not exceeding four inches. Gray coarse granite also crosses Stewart Lake Brook a few hundred yards up, and there are, no doubt, several other small masses between Squint and Armstrong Brooks, judging from the great alteration and disturbance of the rocks. Red granite. Mount Misery.

The fifth and last mass comprised in the Country Harbour granite area is that of Sherbrooke, interesting in itself, but much more so on account of its relation to the Sherbrooke or Goldenville mining district. It lies one-half to three-quarters of a mile west of the Sherbrooke road, extends northward to the foot of the highest of the upper Indian Harbour Lakes and to the road to the marshes of Archibald Brook, eastward to the foot of the lowest of the upper Indian Harbour Lakes, where it runs along A. Jordan's Brook, and southward to within half a mile of Mitchell Lake Brook, near the black slate belt. The Indian Harbour Lakes lie within this mass in a narrow valley, between bold cliffs three to four hundred feet high. The granite forming these cliffs often splits into rectangular slabs, the predominant joints running in an easterly and westerly direction. It is thus easily removed for building, in blocks of all dimensions; it has been quarried to a small extent east of the highest lake, and used in the construction of the piers and abutments of the iron bridges of the district, and also for other purposes. Two or three hundred yards west of this lake, and a little north of the granite quarry, a contact was observed on the face of a cliff, where the granite runs between beds of quartzite, while at the base it overlies and cuts the quartzite, dipping to the north at an angle of 70°. The granite is porphyritic and generally whitish-gray, but for the first two or three feet from the contact it takes a red colour, Fifth mass. Sherbrooke. Indian Harbour Lakes. Quarry.

due to the large proportion of red felspar, becomes coarser and has larger scales of mica, the quartzite or whin being much altered.

Descriptions by Dawson and Hind.

This contact appears to be that figured and described by Sir J. W. Dawson in his Supplement to Acadian Geology, page 84. About forty yards north of it, a two-inch vein of fine granite, with very little mica, intersects the quartzite at an angle of 35°.

Bold cliffs of gray coarse granite border the eastern side of the Sherbrooke Lakes, on which interesting contacts have been described by Professor H. Y. Hind.*

Wine Harbour gold-district.

About a mile east of the post-office at St. Mary's Bay, the surface of the hill is covered with large rectangular blocks of granite, probably derived from an underlying mass of small extent, the nearest to the Wine Harbour gold-mining district, which is three miles and a half distant.

Dykes, long and numerous.

Melrose.

4. *Granite Area of West River, St. Mary's.*—This area is entirely occupied by dykes and long narrow bands of granite, extending along the northern escarpment of the Lower Cambrian rocks, from Melrose to the Cameron settlement. The country in the vicinity of Cochran's Hill, Rocky Brook, Waternish and Melrose is crossed by many dykes, those that have been seen and marked on the map certainly forming but a small part of the large number existing. Their relation to the surrounding rocks is nearly the same in every case. In width they vary from ten feet downward, and in many cases exceed a mile in length, following the bedding, but, like the auriferous quartz-veins of this district, often passing from one plane of bedding to another, which they again leave further on for a third, or thin out. In other cases,

Veins.

Cochran's Hill and Crow's Nest gold-district.

little fissure veins leave the main dyke to cross the bedding, but are generally short. Granite veins, crossing the auriferous measures at Cochran's Hill, and the dyke to the south of the Crow's Nest, afford good examples of such contacts.† At the latter, the slate is, at the junction of the granite, altered into perfectly crystalline schist, largely composed of beautiful crystals, over an inch in diameter, which proved, on examination by Mr. Hoffmann, to be staurolite. The granite of the wide veins is coarse, while that of the smaller veins is often very fine, with little mica, and passing into quartz-felsite or quartzite.

Other veins of granite were also seen, one crossing the Rocky Brook at a ten-feet fall two miles due east of Cochran's Hill gold-mine; another, in a bold cliff on the east side of St. Mary's River, three-quarters of a mile above the Waternish post-office; and another, crossing the

* Sherbrooke Gold District; Journal of the Geological Society of London, Vol. XXVI., pp. 468-479; "Report on a Gneissic Series underlying the Gold-bearing Rocks of Nova Scotia," Halifax, N.S., 1870.

† Supplement to Acadian Geology, pp. 84 and 85.

road on the west side of the river, a quarter of a mile below the Crow's Nest.

Two prominent bands of granite run approximately parallel with the Lower Cambrian strata along their northern escarpment. The eastern band begins one mile and a half east of Melrose, where it is overlain by Carboniferous rocks, and runs a few degrees south of west for a distance of more than twelve miles, crossing the Sherbrooke road one mile and a half below Melrose and the East and West Rivers of St. Mary's, at the Glenelg bridges, approaching the river at Smithfield silver mine, crossing Churn Brook and the road to Smith's bog, half a mile up, passing on the north side of Cranberry Lake, striking McDonald Mill-brook one mile and a half up, and ending at the upper lake of Francis Gut Brook. The eastern part, as far as Glenelg bridge, is seldom over one hundred yards wide; from this point it gradually widens, and at the McDonald Mill-brook, exceeds three-quarters of a mile in width. Where it crosses a small branch of McKeen Brook, one mile and a half east of Melrose, immediately below the Guysborough road, the granite passes into a dark-green or reddish, coarse felspathic and hornblendic fragmentary rock, which continues down the brook for some hundred yards. Twenty yards further, begins coarse, friable Carboniferous sandstone. Immediately above the road is a bluish-black, crumbly, plastic slate, apparently crushed by a fault. From this point, as far west as Glenelg, the dyke is composed of dark-gray, fine granitoid gneiss, with little or no mica, resembling that of Sandy Cove Brook. The western end is also largely composed of granitoid gneiss, generally coarser, and of a light-reddish and whitish-gray color, but also of true granite. On the Churn Brook, at the edge of the band, granitoid gneiss is apparently bedded between layers of altered quartzite; and about half a mile higher up is a small dyke of similar gneiss.

Prominent bands of granite.

Contact with Carboniferous at Melrose.

Silver-mine.

The other band begins three-quarters of a mile north of the western end of the last, or half a mile south of Hattie's bridge, and runs almost due west, with the Carboniferous on its north and the Lower Cambrian on its south side. For four miles it has a regular width of one-eighth of a mile, and runs along the road south of the river as far as Mitchell's Mill-brook; after which it is, for over two miles, overlain by Carboniferous conglomerate largely composed of its detritus, but appears again in a dyke, one or two hundred feet wide, crossing Chisholm Brook and the road to Big Liscombe Lake, half a mile south of the river, and extends seemingly three miles further west, up to the Trafalgar granite area. This band is composed of granitoid gneiss similar to that of the western part of the last band.

Hattie's bridge.

Big Liscomb Lakes.

5. *Trafalgar Granite Area.*—Of this extensive area, only the eastern portion has been examined. It is bounded on the south-east by the Second Rocky, Bruin, Hungry and Big Liscomb Lakes; on the east, by Big and Little Liscomb and Chisholm Lakes; while the northern boundary from Chisholm Lake follows the south side of the West River road as far as Dorman Brook, where it passes a quarter of a mile south of it; crosses the south branch of the West River one mile above the bridge, and the Musquodoboit road three-quarters of a mile west of Porcupine Lake; it keeps a little north of Hattie's Lake, but was not followed further west.

Distinct varieties of granite.

The granite of the eastern end of this mass is mostly whitish-gray, coarse and porphyritic; while that to the westward of the south branch is of finer grain, foliated and porphyritic, generally holding black mica, which gives it a dark-gray color. This area and that of the West River of St. Mary's require to be examined more minutely, and their description must therefore be deferred to another occasion.

The mode of occurrence of the granite in these two masses appears to differ from that of the three eastern areas.

C. Lower Cambrian Rocks.

Fossils discovered by Dr. Selwyn.

No fossils have been found in any of the gold-bearing strata, except the *Eophyton* discovered by Dr. Selwyn at the Ovens, and other forms now regarded as of inorganic origin. Of their age, Dr. Selwyn thus speaks: * "The geological position and the age of these rocks has been fully discussed by Dr. Dawson, and by other of the authors whose observations I have alluded to, and all are agreed that they probably belong to the Lower Silurian period. My first impression of them, formed after personal examination last summer, and based on mineralogical and stratigraphical considerations only, was that they represented the groups known in Britain as the Harlech grit or quartzite and the Lingula-flag series."

Age.

Since then, Sir J. W. Dawson,† Dr. Honeyman,‡ Professor Hind, and others have adopted and maintained the same views regarding the age of these rocks. Mr. Alexander Murray § compares them with the auriferous strata of his Intermediate series of Newfoundland, as follows:

Corresponding rocks in Newfoundland.

"The resemblance in general character of the strata with their included auriferous quartz-veins in Newfoundland to those of Nova Scotia, must strike anyone who has visited the two countries with the purpose of studying their geological features; and I venture to say

* Geol. Survey Report for 1870-71, p. 269.
† Supplement to Acadian Geology, p. 81.
‡ Trans. N. S. Inst. Nat. Sc., Vol. VI., p. 52.
§ Geological Survey of Newfoundland, 1880, p. 535.

that the description given of the latter country by Dr. J. W. Dawson, might, in many respects, equally apply to the former; although according to that author, the auriferous country of Nova Scotia is supposed to be of Lower Silurian age; while that of Newfoundland is undoubtedly unconformably below the Primordial."

In 1878, Sir J. W. Dawson, adopting Dr. Selwyn's views of 1870,* places them below the Acadian series of St. John, New Brunswick, as corresponding to the Longmynd series, Harlech grit and Llanberis slate of England. They certainly, in many respects, resemble the Cambrian rocks of the Eastern Townships described by Dr. Ells.† Like them they are auriferous and cut by masses of granite which alter the slates into staurolite and andalusite schists and the "whin" or quartzite into gneiss; all are very much twisted and wrinkled. Some analogy may also be found between these rocks and those of the Lake of the Woods, described by Mr. A. C. Lawson.‡

Comparison with the rocks in the provinces of Quebec and Ontario.

Nothing more definite can be said at present as to the exact horizon of these rocks, but we may hope that, as in England, further examination will lead to the discovery of fossils, by which this question can be decided; for, it must be remembered that in the greater part of the country examined so far, granite masses and dykes have altered the strata to such a degree as to destroy all traces of organic remains. The gold-bearing rocks are represented in this district by measures over 15,000 feet in thickness, presenting only a few varieties of quartzite, mica slate, or graphitic clay-slate; the quartzite contributing three-fourths of the whole. These rocks, always greatly altered, are metamorphosed to a much higher degree wherever they are cut by masses of granite, and in Canso and Tor Bay districts for example, have been rendered thoroughly crystalline, the quartzite generally passing into fine gneissic rock, the mica-slates into mica and andalusite or staurolite schists and the bluish-black clay-slates into twisted, dark, compact siliceous staurolite or andalusite slates. No limestones have so far been discovered in these strata.

Thickness.

Granite.

No limestone.

Mr. J. Campbell § has divided these Lower Cambrian rocks into two groups, a lower or "quartzite group" and an upper or "lower clay-slate group." This division appears to be natural and will here be adopted, the name of the upper group being, however, changed to a more characteristic one, thus:

Campbell's subdivisions.

1. Lower or Quartzite Group.
2. Upper or Graphitic and Ferruginous Slate Group.

* Supplement to Acadian Geology, p. 92.
† Geol. Survey Report for 1886, Part J.
‡ Geol. Survey Report, for 1885, Part C C.
§ Nova Scotia Gold-Fields, 1863.

C 1. Lower or Quartzite Group.

Thickness of the quartzite group. This group, which is over 11,000 feet thick, is mostly composed of the dark-gray, reddish or greenish quartzose rock called by the miners "whin," a term used in Scotland for an igneous rock resembling trap or basalt. This Nova Scotia whin is a compact or granular quartz-rock or quartzite, containing minute scales of mica uniformly distributed in a direction parallel to the bedding and to the cleavage; but when they do not correspond, presenting upon a fresh fracture, a very characteristic glittering surface. When the mica attains a large proportion, the quartzite becomes gneissic and can be split into large thin slabs, as often occurs in the vicinity of granite. It frequently shows rusty stains in small streaks, also parallel to the bedding or cleavage, and due to the arsenical and iron pyrites with which the rock is always highly charged. Certain thick beds of coarse quartzite contain large cubes of iron pyrites often over an inch in diameter. This coarser rock is generally found in beds several feet thick; but the average thickness of the beds of quartzite is usually not more than two feet, while some of the slaty and fine granular varieties are in beds between one and four inches thick.

Pyrites.

Slate. Interstratified with the quartzite are numerous bands of slate, usually less than a foot, but sometimes seventy-five feet thick; the principal varieties of slate are light-gray glistening mica-slate, almost wholly composed of mica; dark-bluish, papery, shining, fine micaceous slate; dull-gray, dirty, rusty, arenaceous, earthy slate; greenish, soft, unctuous slate with little mica; and bluish-black or dark bluish-gray compact siliceous slate, generally metalliferous and holding arsenical and iron pyrites in crystals or nodular masses, principally in the vicinity of auriferous quartz-veins, with which they are often associated.

Auriferous veins.

Conglomerate. To this group belongs also a very flinty, compact conglomerate, six or seven hundred feet below the summit of the group, noticed in two places; and an auriferous or barren quartz, forming numerous veins apparently interbedded.

The base of the quartzite group is characterized by the occurrence of coarse quartzite and grit in thick beds which, at the mouth of the St. Mary's River, appear to be underlain by bluish-black and greenish siliceous slate holding small crystals of andalusite or staurolite.

The thin bands of slate are more numerous and of greater thickness at the middle of the group, where they are associated with auriferous quartz-veins.

C 2. Upper or Graphitic and Ferruginous Slate Group.

The black slate group is separated from the quartzite group by a few layers of greenish, soft, smooth slate which becomes darker as it

approaches it and insensibly passes into it. This upper group has a thickness of over 4,000 feet, and is wholly composed of bluish-black, ferruginous and graphitic slates, easily distinguished from and unlike any others in the province, having a very characteristic fibrous-texture. Certain flinty layers are full of arsenical and iron pyrites distributed through the mass in small, perfect crystals. In the vicinity of masses of granite, these slates are wrinkled and full of beautiful pearly crystals of andalusite and staurolite, sometimes an inch and a half long, and one eighth of an inch in diameter, but sometimes short and stout. Small crystals of red garnet are also often found near the contact.

Thickness of the upper group.

Andalusite, staurolite and garnet.

General Structure of the Lower Cambrian Rocks.

These rocks have been greatly disturbed from their original horizontality as sedimentary rocks by a powerful but uniform pressure from the south, which has folded them into a series of sharp parallel undulations. But by denudation they have been so worn down that the crowns of the anticlinals have been cut off, leaving the upturned edges of the strata. The rocks generally dip at an angle varying between 75° and 90°, seldom lower than 45°, and the strata are often overturned. In the more altered portion, the planes of bedding are not easily distinguishable from those of the slaty cleavage, which are often much more distinct than the former. The course of the undulations is about east and west (astronomical). Between Canso and New Harbour River, the strike is S. 76° W. and N. 76° E., and between New Harbour and Sheet Harbour Rivers, S. 84° W. and N. 84° E. The folds are thus roughly parallel to the northern boundary of these rocks, and as the sea-shore runs about south-west, they are obliquely cut along the Atlantic shore, where good sections are displayed. Their breadth increases from Cape Canso westward, and at Sheet Harbour River, it attains thirty-two miles.

Folding.

Cleavage.

Extent.

No less than eleven principal anticlinals and as many synclinals have been defined between the islands off Sheet Harbour and Caledonia. The gold-mining districts are all situated on these anticlinals, so that their accurate location is of great practical value towards the discovery of new gold-fields. They have been followed eastward as far as Country Harbour, where a great fault, running north-west up the harbour, apparently cuts them and shoves the rocks on the east side about four miles north. Their relation on the opposite sides of the harbour, however, has not yet been studied sufficiently to ascertain the nature or even the positive existence of the fault.

Gold-districts on the anticlinals.

Faults.

East of Country Harbour, and in many parts of the interior between this and Cape Canso, the anticlinals cannot be mapped with as much

accuracy as to the westward and along the shore, the dislocations caused by masses of granite having disturbed the regularity of the folds which require to be studied with more detail. An extensive fault probably follows the northern boundary of the Lower Cambrian rocks from Chedabucto Bay to beyond Trafalgar. The reasons for this conclusion are the remarkably straight course of the boundary line between these two points, the unbroken escarpment on the south side and the occurrence, near Melrose and other places along its direction, of crushed black slates and quartzites with slickensided surfaces, deeply striated and coated with red hæmatite. Its straight course is interrupted, however, near Country Harbour Cross-roads by a subsequent line of faulting which crosses the other, and has caused on its east side a shove to the north, of three or four miles, corresponding with the Country Harbour fault just mentioned.

Many other faults of more or less extent, have been noticed in different places, and these form no doubt but a very small proportion of the large number to be expected in such a disturbed district, especially in the vicinity of granite masses.

Surface Distribution of the Lower Cambrian Rocks.

It will be found convenient, for several reasons, to sub-divide the region between Cape Canso and Sheet Harbour River into four districts, as follows:

1. Chedabucto Bay District.
2. Isaac's Harbour District.
3. Indian River District.
4. Liscomb, Moser's and Salmon Rivers District.

Area.

1. *Chedabucto Bay District.*—This district has an area of about 275 square miles, and lies south of Chedabucto Bay, from Cape Canso to New Harbour River. The Cape Canso and Tor Bay granite areas, described before, pages 133 and 135 P, are included in and occupy about half of this district, the remainder being covered with flinty, quartzose schistose and gneissic rocks.

Granite.

Some authorities have supposed these to be older than the gold-bearing rocks, but upon examination, it is clearly seen that they are the continuation of the Lower Cambrian rocks of the western districts, which have become thoroughly crystalline, more especially when in close contact with the granite.

A glance at the map will show this continuity of the strata. Two synclinals, crossing the New Harbour River above the Third Fork and exhibiting bluish-black graphitic slates with all the characteristics

Black slate.

of the upper group, have been traced eastward beyond the head of the North-west Arm. These slates change greatly as they approach the granite, but always keep their charactoristic bluish-black color, and woody, fibrous texture. At the immediate contact, however, they become so crystalline that the rock is almost wholly composed of crystals of staurolite and andalusite, associated with others of garnet, hornblende, tourmaline, chlorite, etc. The quartzite group brought up by anticlinals can also be traced from the head of the New Harbour River eastward as far as Cape Canso. The gradual passage of the quartzite and associated bands of slates into flinty quartzose micaceous rocks, fine gneisses, gray mica-schists and pearly slates, is also well marked. Contact of slate and granite.

No less than seven anticlinals and synclinals are found between the Eastern Head of New Harbour and Salmon River, running a few degrees north of east, and bringing successively to the surface the quartzite and graphitic slate groups, in belts, which have been separated and are shown on the map, so that little need be said here concerning their distribution. It may be remarked, however, that, although these belts have in many cases been replaced by the different masses of granite, as a rule, the disturbance is less than might, perhaps, be expected. Anticlinals.

The strata sometimes dip away from masses of granite of the Tor Bay area, but more frequently maintain their normal strike up to them on one side and resume it again on the other. The granite, indeed, has not merely pushed aside the strata in making its way through them, but actually occupies the place of so much quartzite and slate, which have disappeared, as if cut off or lifted up by the granite and subsequently worn away. In this district, a larger area is covered with the upper slate group than in any of the others. Large area of slate.

The structure of the wide belt of bluish-black graphitic slate of this age, at Whitehaven, between Marshall Cove and the mouth of the Wash Brook, and stretching eastward to Larry's River, has not yet been clearly made out. Two bands, over a quarter of a mile wide, of pearly, glistening siliceous rock, full of stout, short crystals of andalusite, occur in this belt, separated on both sides from the black slate by a few hundred yards of quartzite and gray slate, resembling rocks of the quartzite group, while the andalusite rock is unlike any other in the district. One band extends westward from the Spear Lake, crosses the Whitehaven road at its junction with the Port Felix road, passes at the head of Port Felix Cove, a little above the school-house, is shown at the outer part of the western point of English Cove, and along Charlo's Cove, and extends perhaps to Larry's River, half a mile above the chapel, where much *débris* is seen. The other appears at Poulet Point, and further north, along the shores of Whitehaven and Whitehaven.

Port Felix. They seem to come in on two of the three synclinal axes in the black slates, and thus most probably overlie them; in which case we have here a group of rocks newer than the graphitic slate, which it would be interesting to compare with the upper divisions of the Cambrian of the Eastern Townships.

Rocks higher than the black slate group.

New Harbour fault.

A close examination of the quartzites on both sides of New Harbour Cove indicates a fault running along the harbour. The well defined anticlinal and synclinal on the east side are repeated on the west side, but are here about a quarter of a mile further south, and have also changed considerably in direction, the result of a displacement of about a quarter of a mile to the north on the east side of the line of faulting. The rocks on both sides are crossed by numerous veins of quartz running north and south across the strike.

Quartz veins.

The belt of bluish-black slate which crosses New Harbour River at the mouth of Patterson Brook, appears also to have been subjected to a break of about the same amount, but nothing very definite can be said about it. This fault probably extends north-westward along New Harbour River, the boundary of the granite, and thence in a northerly direction to the Salmon River fault, thus dividing the Chedabucto and Isaac's Harbour districts. This supposition is strengthened by the remarkable straightness of the lower part of New Harbour River, which nearly coincides with the boundary of the granite; but the direction of the part running north, from a little above the Third Fork, is very indefinite. A broad synclinal probably passes near the east end of Loon Lake and runs north to Salmon River, toward which the axes of the synclinals and anticlinals dip on both sides. This would account for the many belts of bluish-black slate branching off in that vicinity, and for the thinning of the whin belts from both sides.

Area.

2. *Isaac's Harbour District.*—This district extends from the line of fault at New Harbour River to Country Harbour, and from Salmon River to the sea-shore. In the northern portion are many masses of granite, in the neighborhood of which the stratified rocks assume, like those of the first district, a schistose or gneissoid character. Blocks of quartzite and granite are very abundant, but outcrops are rare; this fact, together with the total absence of the bluish-black slate, makes it impossible to ascertain the structure.

Granite.

Black slate.

The southern part of the district is crossed by two bands of bluish-black slate. One of these, already referred to, crosses the New Harbour River, but apparently runs no further west than the south end of Ocean Lake. The other crosses Isaac's Harbour, a few hundred yards above the post-offices on the east and west sides, in a deep, sharp synclinal, which extends due west as far as Country Harbour, and prob-

ably not more than two miles and a half east of Isaac's Harbour. But the synclinal axis still continues its course eastward, passing immediately south of Sponagle and Barss Lakes to New Harbour Cove, where it has been already mentioned.

About a mile south of this axis, an anticlinal runs parallel with it as far as Country Harbour in one direction, and New Harbour in the other. It passes immediately south of the main shore of Coddles Harbour, where the strata are beautifully exposed and dip N. 17° E. < 45°–55° ; but further east, the angle gradually decreases, and, within three-quarters of a mile of New Harbour Head, the rocks are seen dipping both ways, and the axis itself dips a little south of east at an angle of 20°. The same also occurs on the New Harbour end of the anticlinal. **Coddles Harbour anticlinal.**

The auriferous measures worked on the east and west sides of Isaac's Harbour lie on both sides of this anticlinal. **Isaac's Harbour gold-mines.**

3. *Indian River District.*—This district includes the Lower Cambrian rocks between Country Harbour and St. Mary's River, and is mostly drained by Indian River and the Indian Harbour chain of lakes. **Extent.** The strata along the west side of Country Harbour are well exposed, and belong to the lower group. The structure is sufficiently clear, as may be seen on the map, where the anticlinal and synclinal axes are indicated. **Folds.** The section on this side, however, does not, as already stated, seem to correspond with that on the east side, but is obscure, for want of good outcrops. The question of the existence of a fault in the harbour must be determined by more detailed examinations on the east side, although the small dykes of granite running parallel with the harbour, between Squint's Brook and Armstrong Creek, the many lines of dislocation of the highly altered strata, also following the harbour between Mount Misery and a point three-quarters of a mile above the mouth of Armstrong Brook, and the numerous slickensided surfaces, are strong proofs of its existence. **Faults.** Moreover, no sign of the Isaac's Harbour bluish-black slate is seen on the west side, the nearest belt being on Fisherman's Harbour, more than four miles south, and the nearest synclinal one mile and a half south, that is, a quarter of a mile below Lucas Beach, exposing none of the upper slate group. There is nothing to show which of these two axes is the continuation of the synclinal of Isaac's Harbour, except that the sharpness and structure of the synclinal of Fisherman's Harbour, together with its bluish-black slate, make it resemble more closely the latter. The northern part of this district, like the preceding, is cut by numerous masses and dykes of granite which have metamorphosed the surrounding rocks for a width of one mile or more. **Granite.**

Auriferous belt

The auriferous belt brought up by the most northerly anticlinal of the district, and running from Cochran's Hill to the Narrows of Country Harbour, is disturbed by many dykes and veins of granite, already described, and has numerous true quartz-veins intercalated. The auriferous measures up Johnson's Brook, on the east side of Country Harbour, are apparently the same rocks, but run in a direction different from that of any other strata of this region, their general orientation being N. 20° W. along the western face of a mass of granite. This belt is undoubtedly the continuation of that of Cochran's Hill, faulted either by the Country Harbour fault or by some local dislocation produced by the upheaval of the granite.

Johnson's Brook.

Cochran's Hill.

Black slate.

Between a mile and a mile and a quarter south of this Cochran's Hill belt, a band of graphitic slate is left undenuded along the axis of a synclinal. It is seen at Waternish, and extends westward beyond the St. Mary's River, the southern edge of the band crossing the Sherbrooke road at the bridge over Cochran's Hill Brook which exposes a section of the whole band. It extends north on the brook to a forty-feet fall, which makes a width of nearly half a mile. From this brook it apparently runs due east, being seen from a quarter to three-quarters of a mile north of the Bull-ridge; but it seems to extend no further, no trace of it being seen below the Head Lake. The irregularity in the strike and dip of the rocks here, clearly shows that they have been greatly disturbed by the adjacent granite and that the lower group has been brought up along the synclinal axis in its course eastward. No indication of the upper group is then seen till Country Harbour, in the vicinity of Charles Hind's farm opposite Stormont post-office. At Cochran's Hill, the strata on the north side of the synclinal, present an overturned dip to the north, varying between 60° and 85°, as far as the auriferous belt which is here about one mile below the lowest bed of the graphitic slate group. At Country Harbour, the dips seem to average 45° on both sides of the synclinal, but the outcrops are obscure.

Waternish synclinal.

Lower group.

The lower group occupies all that portion of the district lying between the Waternish band of slate and the next, which is about two miles below Sherbrooke. It is folded in at least two principal anticlinal curves and one synclinal, the position and course of which, although not always well defined, have been mapped as accurately as possible. The most northerly of the anticlinals is about three miles south of the Waternish slate belt, but the intervening strata are no doubt affected by other folds of less magnitude, as is also the case along Country Harbour, where an anticlinal and a synclinal are met with within a quarter of a mile of each other. This first anticlinal crosses Stillwater about half a mile below the school-house, thence follows the west branch of Archibald Brook, and probably strikes the west

Folds.

Stillwater anticlinal.

side of Country Harbour half a mile above Mount Misery. The strata on both sides of this axis generally dip at an angle varying between 70° and the vertical, except above Falconer's Lake, where the angles are as low as 45°.

A few auriferous quartz-veins have been prospected in the vicinity of the anticlinal on Alexander McDonald's farm. Although greatly altered, the strata are not near any masses of granite, but are no doubt associated with dykes or veins, only one of which, however, has been observed at the outlet of Archibald Lake. Many blocks of granite occur in the vicinity of this axis, a little below the second fork of Indian River, perhaps derived from a neighboring dyke or small mass. From a mile to two miles south of this anticlinal the strata are affected by a minor fold, extending no great distance to the eastward of St. Mary's River, but forming to the westward two of the principal axes of the next district.

The next principal plication is the Sherbrooke synclinal, about three miles south of theStillwater anticlinal, a well defined and comparatively broad synclinal bringing to the surface the upper strata of the lower group. It crosses the Sherbrooke road 1,000 feet above the English church, and is well seen on the north-west side of the track to Indian Harbour Lakes, as a semi-elliptical basin, the longer axis of which runs south of west across the river, where its prolongation is also one of the principal synclinals of the next district. To the eastward, its strata come in contact with the Sherbrooke granite, and may be said to dip away from it, although some of the contacts, when examined minutely, show clearly that they are cut by the granite, as if the latter had partly pushed upward the strata of the synclinal and partly cut through them. The synclinal, on the opposite side of this granite mass, apparently resumes its course eastward, and extends to Country Harbour, a quarter of a mile below Lucas Beach, where it is also very broad. The strata, quite horizontal at the axis, dip to the north at an angle gradually increasing from 10° to 70°, while on the south side the dip increases to 62°, and averages about 35°. No sign of the graphitic slate was seen in this synclinal, but it evidently displays the very top of the lower group, as may be seen by comparing its section along the western side of Country Harbour with that of the synclinal of Fisherman's Harbour.

Sherbrooke synclinal.

Lucas Beach.

About one mile and a half south of the last axis comes the Goldenville anticlinal. The part of this axis west of the Sherbrooke granite, to a little beyond Goldenville, has been well described by Professor Hind in his report on the Sherbrooke gold district.*

Goldenville anticlinal.

Hind's description.

The strata on the point of land south of Mill Cove are seen, on the

*Journal of the Geological Society of London, Vol. XXVI., pp. 469-479.

face of a small cliff, to lie quite horizontal; in proceeding north, they dip to the north at a low angle gradually increasing to 50° on the Sherbrooke main street, where the Goldenville road leaves it, and then decreasing to the last synclinal. Less than a hundred yards to the south of the cliff, on the other hand, the strata suddenly dip perpendicularly, and are even overturned to the north 70° between this point and the St. Mary's Bay synclinal, two miles further down. The granite mass has here also pushed up the strata considerably, giving a western dip to the anticlinal axis. The rocks are found to continue their course on the opposite side, and still form an anticlinal, running eastward along the West Branch of Indian River and Squint's Brook, and coming to the shore of Country Harbour, a quarter of a mile below the mouth of this brook. Here, as at Sherbrooke, the steep side of the axis is on the south, where the angle of dip averages 84°, while the north side is more gently inclined. Many quartz-veins, one foot thick and less, run along the anticlinal, about one hundred yards south of the first fork of Indian River; they will be again referred to

Influence of the granite.

Squint's Brook.

Quartz-veins.

St. Mary's Bay synclinal.

The next fold is nearly two miles south of the Goldenville anticlinal and presents the deepest and most persistent synclinal axis of the region. It offers a very good section of the graphitic slate group, for nearly three-quarters of a mile on both sides of the St. Mary's River from the mouth of Mitchell Lake Brook to about two hundred yards below the school-house. The band of slate runs due east along Mitchell Lake Brook, takes in the southern part of the lake, and extends to within a short distance of the lower Indian Harbour Lake, where it is cut by a fault, but, about half a mile further north, shows again on both sides of the lake, still running east and west. This fault, as already mentioned, seems to run from Indian Harbour, a short distance below the beach, north-westerly to the Sherbrooke granite, and most probably from the northern side of this mass to Melrose; for the strata have been greatly disturbed immediately east of the St. Mary's River, and have all received a twist which may be accompanied by a fault The total shove here on the east, including the twisting, is one-half or three-quarters of a mile to the north, or about the same as that of Indian Harbour, and there is good reason to believe that it is also due to the upthrow of the Sherbrooke granite. The width of the slate band on Indian Harbour Lake is very little over a quarter of a mile; it crosses the lake about half a mile above the beach, and runs a few degrees north of east to Indian River, which it crosses from a quarter of a mile to one mile north of the shore road, thence running due east in a low, swampy depression, to Fisherman's Harbour. The northern edge of the band is, at low tide, well exposed on the north shore of the harbour, where the bluish-black splintery slate,

Black slate.

Fault.

Indian Harbour

Fisherman's Harbour.

dipping south at an angle of 75° to 85°, is followed by layers of greenish argillaceous slate, succeeded by a few thin layers of quartzite and gray slate, and for nearly a mile up the east side of Country Harbour Head, by a good, uninterrupted section of the quartzite group which shows many intercalated veins of quartz. The southern edge of the band of slate undoubtedly keeps along the south side of the harbour, but no outcrops have been noticed here. The rocks on both sides of this synclinal, dip at angles varying between 80° and 90° and are even overturned.

Country Harbour Head.

Good section of the quartzite group.

About one mile and a half south of the St. Mary's Bay synclinal is the Wine Harbour anticlinal axis. It crosses the St. Mary's River half a mile below Pride's ferry, passes eastward to the foot of Cooper's Lake, and comes to the sea-shore a little above Rude Point, where the strata are well exposed and the fold well defined. As at Goldenville, the strata on the south side of the axis dip at a very high angle, while on the north, the angle of dip, quite small near the fold, gradually increases to over 80° on approaching the last synclinal. The Wine Harbour auriferous district extends immediately south of this line of folding. The anticlinal is also seen further west on the sea-shore, halfway between Port Hilford and Holland's Harbour, but is here over three-quarters of a mile north of its course at Wine Harbour, this difference representing the extent of the shove it has received from the Indian Harbour fault, and proving that the line of fault lies between the shores of Indian Harbour. Eastward, the Indian Harbour anticlinal keeps along the northern shore of Holland's Harbour, and passes somewhere near the post-office at Port Beckerton and a little north of the southern extremity of Barachois Head.

Wine Harbour anticlinal.

Fault.

The next and last fold of this district is about one mile and a quarter south of the Wine Harbour anticlinal. It crosses the St. Mary's River near the Sonora church, and runs to the sea-shore immediately south of Wine Head, a distance of a little over four miles. On the west side of the river it presents a large exposure of bluish-black slate, and a band of this slate certainly keeps along this axis as far as Wine Head, although only a few blocks and débris of the slates are seen all along and a small exposure near the head; for the thickness of the strata, measured between the Wine Harbour anticlinal and the lower beds of the bluish-black slate group of the St. Mary's Bay synclinal, being very little over a mile, and that between the strata of the same anticlinal and the Sonora synclinal being greater, a certain thickness of the bluish-black slate must represent the difference.

Sonora synclinal.

Black slate.

4. *Liscomb, Moser's, and Salmon Rivers District.*—This district lies west of that last described and includes the Lower Cambrian rocks

Extent. between the St. Mary's and Sheet Harbour Rivers. Its length between these two rivers is thirty miles, and the breadth at its widest part, thirty-two miles between the islands off Sheet Harbour and Caledonia. The general direction of strike of the rocks is S. 80° W. and N. 80° E. and in no case does it vary more than 10° on either side of this course.

Granite. The two bands composing the granite area of the West River of St. Mary's in the northern part of this district and that of Trafalgar, which forms, however, its western limit at the Liscomb Lakes, are the only masses of granite which occur; and the few much-altered rocks are altogether confined to their neighborhood, with the exception of those near the Salmon River mine. These consist of a silvery-gray staurolite-gneiss found in blocks along the river a little above the crusher, undoubtedly derived from the country rock in the proximity of some mass or dyke of granite which does not, perhaps, quite reach the surface. The beautiful aggregations of transparent crystals of quartz often found in the thick leads of this mine with calcite, galena, pyrites and other minerals, must also be due to the same mass. Many small local faults have been noticed in various places, but none of such extent as to affect the general structure of the strata as in the districts just described, and this is no doubt due to the scarcity of granite masses or their non-appearance at the surface.

Salmon River mine.

Faults.

Flexures. Deep synclinals and lofty anticlinals here succeed one another very regularly; so that whenever a band of the characteristic graphitic slate occurs along a synclinal, it is always found on the opposite side of the following anticlinal at the same distance (reduced according to the angle of dip). The folding process seems to have been slow and uniform and to have occurred when these rocks were still plastic, otherwise they would have been greatly faulted.

Eleven anticlinals. Eleven principal anticlinals and as many synclinals have been traced between Beaver Island off Beaver Harbour, and Caledonia; four of them are the continuation of those in the Indian River district. Some have been accurately defined and mapped, but others, especially the anticlinals, require careful re-examination on account of their close relation with the gold mines.

For this reason it will be better to simply enumerate them and to defer for the present, a fuller and more accurate description.

Beginning with the most northerly, the eleven anticlinals and synclinals alternate as follows:—

1st. Synclinal: runs from Fraser Brook about 2,000 feet above West River to McQuarrie's Mill-brook, half a mile above the same river, and is overlain at both ends by Carboniferous strata.

1st. Anticlinal: Cochran's Hill auriferous belt; passing westward by the north end of Kelly's Lake.

2nd. Synclinal: not traced.
2nd. Anticlinal: follows Little Liscomb River from Methiff's Brook to its source, but was not traced east or west of this river.
3rd. Synclinal: Waternish synclinal; extends to Rocky Lake of Crooked Brook and beyond.
3rd. Anticlinal: not traced, but passes a mile south of the confluence of Big Brook and Liscomb River.
4th. Synclinal: not traced, but seen at the confluence of Crooked Brook and Liscomb River, and below Moose-bog Camp.
4th. Anticlinal: passes near the Dreadnaught dam and at the cofluence of Black Brook and Liscomb River, where it shows leads said to be auriferous.
5th. Synclinal: Sherbrooke synclinal; extends to the Long Lake of Moser's River and beyond.
5th. Anticlinal: Goldenville anticlinal; passes at the Rainbow, Moser's River, on its course westward.
6th. Synclinal: St. Mary's Bay synclinal; crosses Shoaly and Cross Lakes of Salmon River.
6th. Anticlinal: Wine Harbour anticlinal; runs out somewhere above the Stillwater of Liscomb River.
7th. Synclinal: Sonora synclinal; also runs out near the head of the Stillwater of Liscomb River.
7th. Anticlinal: from Barachois Point, passes a quarter of a mile above Wilson's Fall on Moser's River.
8th. Synclinal: Spar Lake synclinal; begins half a mile north of Liscomb Mill, and extends westward, passing one mile above Salmon River mine.
8th. Anticlinal: Salmon River mine anticlinal; extends westward, but runs out to the eastward near Liscomb River. Brook.
9th. Synclinal: Liscomb Harbour synclinal; from Liscomb Island to Sheet Harbour and beyond.
9th. Anticlinal: Ecum Secum anticlinal; leaves the sea-shore near Lang Pond beach, and passes at Ecum Secum mine, r short distance north of Moosehead and Harrigan Cove mines, crossing Salmon River a quarter of a mile above the bridge at Moorehead and Harrigan Cove mine.
10th. Synclinal: begins along the sea-shore between Barren Island and Smith Point, and passes westward at Beaver Harbour.
10th. Anticlinal: from Tuffin Island runs westward between Back Cove and Beaver Harbour.
11th. Synclinal: begins north of Bird Islands (?) and passes along Sober Island Passage.
11th. Anticlinal: also begins north of Bird Islands (?) and passes between Horse Island and Sutherland's Island.

Of these, seven anticlinals and six synclinals run through the district from one end to the other; the others either begin or end in it. The third, fourth, fifth, sixth, seventh eighth and ninth synclinals display the upper graphitic slate along their course. **Black slate.**

North and south folds merely local.

It may further be remarked that there appears to be no proper north and south anticlinal or synclinal crossing this district all the way from one side to the other; but there are many local ones, sometimes of great extent. One broad synclinal, running approximately north and south, occurs west of the Sherbrooke gold-district, and is described by Professor Hind in his report on the district, already quoted. The axis does not appear to extend far north of this district, and most probably runs west of south to the sea-shore between Bird Islands and Halibut Islands; but whether it is uninterrupted between these two points, has not yet been ascertained. A cross anticlinal may also run between the village of Sherbrooke and Barren Island, and another between Salmon River mine and Sober Island, but nothing positive can be said about them at present.

General Structure of the Gold Districts.

List of reports on the gold-bearing rocks.

Several of the principal gold-districts of the province have been studied minutely and reported upon by different authorities, and more especially by Dr. A. R. C. Selwyn, Dr. T. Sterry Hunt, Dr. B. Silliman, Prof. H. Youle Hind, and Messrs. John Campbell, Henry Poole, A. Heatherington, H. S. Poole, and Edwin Gilpin.

The following list of reports and pamphlets relating to the Lower Cambrian rocks and the gold-districts, given in chronological order, may be of use to those interested in the study of them.

Gesner: Remarks on the Geology and Mineralogy of Nova Scotia, 1836; The Industrial Resources of Nova Scotia, 1849; Gold-fields of Nova Scotia, 1862; Gold and its Separation from other Minerals, 1863, Trans. N. S. Inst. Nat. Sc., Vol. I., part 1, page 54.

Dawson: Metamorphic and Metalliferous Rocks of the Atlantic Coast of Nova Scotia, 1850, in the Journal of the Geological Society of London, Vol. VI., pp. 347-364; On the Recent Discoveries of Gold in Nova Scotia, 1861, in the Canadian Naturalist, Vol. VI., p. 417; Acadian Geology, 1855, second edition, 1868, and supplement, 1878.

Marsh: The Gold of Nova Scotia, 1861, Amer. Jour. of Science and Arts, Vol. XXXII.

Honeyman: Geology of the Gold-fields of N. S., 1862, Quarterly Jour. Geol. Soc. Vol. XVIII., p. 342; Report on Gay's River Gold-fields, 1866, Trans. N. S. Inst. of Nat. Sc., Vol. II., Part 1, p. 76; Micro-Polariscopic Investigation of the Crystalline Rocks of the Gold-bearing series of Yarmouth, N. S., 1882, ditto, Vol. VI., p. 7; Geology of Halifax and Colchester Counties, 1883, do p. 52. Other Notes by the same author are scattered through the Trans. N. S. Inst. of Nat. Sc.

Annual Reports of the Dept. of Mines of Nova Scotia, 1862-1886.

Poole: Report on the Western Gold District of N. S.

Campbell: Nova Scotia Gold-fields, with section, 1863; Report on the Chebucto Gold Mining Co. of Waverly Gold District, 1864; Report on the Indian Path Gold Mine of Lunenburg District, with plan, 1869.

Silliman: A Report on the New York and Nova Scotia Gold Mining Co. of Tangier District, with plan; Report on the Atlantic Gold Mining Co., also of Tangier District, with plan; Report on the Oldham and Boston Gold Mining Co. of Oldham District; the three printed separately in 1864, with a general Introduction on the Gold Region of N. S.; Barrel Quartz of N.S., 1864, Silliman's Jour. 2nd series, Vol. XXXVIII., page 104.

Hartt: Gold of N. S. of Pre-Carboniferous age, 1864, Can. Nat., new series, Vol. I., p. 459.

Perley: Gold Mines and Gold Mining in N. S., 1865, Can. Nat., new series, Vol. II., p. 198.

Belt: The Glacial Period in North America (Gold in the drift of Nova Scotia), 1866, Trans. N. S. Inst. of Nat. Sc., Vol. I., part III., p. 91.

Hamilton: The Auriferous Deposits of N. S., 1866, Trans. of N. S. Inst. Nat. Sc., Vol. I., p. 43.

Hunt: Gold Region of Nova Scotia, 1868, Report of Geol. Survey of Canada; On the Geology of Eastern New England and N. S., 1870, Amer. Jour. Sc. (2), L., pages 87 and 133.

Bell, Barnes and Heatherington: Report on the Eureka Gold Mining Co., with a plan of the Wine Harbour Gold District, 1868.

Hind: Report on the Waverly Gold District with maps and sections, 1869; Report on the Eureka Gold Mining Co. of Wine Harbour, 1869; Nova Scotia Gold Districts, 1869, Trans. N. S. Inst. of Nat. Sc. Vol. II., Part III., page 102; Report on the Sherbrooke Gold District, with maps and sections, together with papers on the Gneisses of Nova Scotia, and on Gold Mining in N. S.; printed in a pamphlet in 1870, and given in abstract in the Jour. Geol. Soc. of London, Vol. XXVI., pp. 468-479; Preliminary Report on the Gneissic series underlying the Gold-bearing Rocks of N. S., 1870; Report on the Strawberry Hill, Burlington and Mooseland Mines of Tangier District, 1870; Gold Mining and its Prospects in Nova Scotia, embodying results of Geological Surveys of the Districts of Waverly and Sherbrooke, 1870; Report on Mount Uniacke, Oldham and Renfrew Mining Districts, with plans and sections, 1872; Report on the Indian Path Gold Mine of Lunenburg District, 1873.

How: Mineralogy of Nova Scotia, 1869.

Selwyn: Notes and Observations on the Gold-fields of Quebec and Nova Scotia; Report of Geological Survey of Canada, 1870-71, p. 252.

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Descriptive Catalogues of Economic Minerals of Canada, 1876, pp. 43–44; 1886, pp. 63–65.

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H. S. Poole: Report of Department of Mines, N. S., 1873–1879; Jour. of Geol. Soc. of London, Vol. XXVI., pp. 307–313.

Gold-mines in operation.

There are ten gold mining localities in the region examined between Cape Canso and Sheet Harbour River. Mining operations are at present carried on in the six following: Darr's Hill or Salmon River, Golden-

ville, Cochran's Hill, Narrows of Country Harbour, Isaac's Harbour and Wine Harbour. In some of these, several mines are or have been worked to some extent. The Dufferin Gold Mining Company of Salmon River is stated in the annual report of the Department of Mines of Nova Scotia for 1886, to have "proved to be the most permanent of the gold mining corporations of the province." During the past year, the returns show that 11,628 tons of quartz yielded 6,509 ounces of gold. being a total to date of 24,556 ounces from 44,881 tons of quartz.

Salmon River mine.

Old mines.

Several years ago work was done to some extent in the four other districts of Old Country Harbour, Ecum Secum, Moosehead and Harrigan Cove, but it has not been resumed.

Auriferous veins not worked.

Many quartz-leads found outside these districts contain also visible gold, but have not yet been worked. Among these are the veins passing a little to the south of the first fork of Indian River; those on Alex. McDonald's farm at Stillwater; those on the west side of Goldenville Lake, and on the portage road on the west side of Liscomb River, a little distance above the mill; the vein crossing the east branch of Liscomb River, a little below the embouchure of the Black Brook; those of the Gold-mine Brook, and that on the east branch of Rabbit-plain Brook. Some of these leads may yet prove rich.

No minute surveys or detailed examinations of the above mentioned gold districts have been made, but a few remarks relating to their general structure may, however, be given.

The auriferous veins near the anticlinal axes.

In examining the map, it will be found that all the gold mines are on, or in close proximity to, the anticlinal axes, and this is also true of the auriferous leads above mentioned.

Distance of the gold belts from the black slate.

The vertical distance of the different gold belts of this region, from the base of the upper graphitic slate, is shown in the following list:—

Name of the belt.	*N. or S. dip and angle of the rocks.*	*Vertical distance to the upper slate band.* FEET.
Consolidated Gold Mining Co. of Isaac's Harbour District	S. < 60°	4,000
Gallagher Gold Mining Co.	N. < 63°	4,000
Victoria Gold Mining Co.	N. < 78°	2,800
Star Gold Mining Co.	N. < 65°	4,620
Wine Harbour Gold District	S. < 75°–85°	4,620
Sherbrooke " "	N. < 45°; S. < 90°	8,000
Cochran's Hill Gold Mine	N. < 80°	4,620
Crow's Nest " "	N. < 87°	6,600
Ecum Secum " "	N. < 70°; S. < 50°	5,940
Moosehead " "	S. < 55°	(?)
Harrigan Cove " "	S. < 65°	(?)
Salmon River or Darr's Hill Mine	N. < 80°; S. < 65°	2,800

It will be seen from this table that all the gold belts occur at a distance below the base of the graphitic slate, varying between 2,800 and 8,000 feet. Should this hold true of the gold belts west of this region, we shall have a thickness of 5,200 feet of productive gold measures out of the total 15,000 feet of the Lower Cambrian, or about one-third. From observations made by Poole, Campbell, Hind and others, such is most probably the case, but nothing positive can be asserted till the general structure of the rest of the Lower Cambrian of the Atlantic coast has been thoroughly made out. Many intercalated quartz-veins are also found in the lower portion of the quartzite group, and in the upper graphitic slate group, not in such large numbers, however, as at the horizon of the auriferous measures; few, moreover, contain gold, and only in very small quantity.

Barren quartz-veins.

Three-quarters of a mile west of the junction, a few quartz-veins, cutting slightly across altered black slates of the upper group, were found to contain traces of gold. Half a mile west of Moser's River, above the saw-mill, a vein of rusty quartz, four feet thick, apparently following the strike of the upper graphitic slate, was opened, but found very poor in gold. It may, therefore, be concluded that the upper part of the series also carries gold, but in very small quantity; but no instances are known in which the lower portion of the quartzite group contains auriferous quartz-veins.

Auriferous veins in the black slate.

Admitting that the horizon of the gold is a little above the middle of the quartzite group, the auriferous measures could certainly be found at the surface, only along the anticlinals by which they have been brought up and where their edges may have been exposed by denudation.

Horizon of the gold.

It has been advocated by Campbell, Hind and others that the gold districts occurred at the intersection of broad north and south upheavals, with the sharp east and west anticlinals. Such is certainly the case with the Sherbrooke and Ecum Secum districts, and perhaps also with that of Salmon River, while the Wine Harbour gold district is rather on a north and south depression, and the others do not seem to be connected with the intersection of an anticlinal with either upheaval or depression; therefore, nothing very definite can be said about them.

North and south upheavals.

The origin, mode of occurrence, and extension of the auriferous lodes have been discussed by Dr. Selwyn, in his report for 1870-71, already referred to.

Origin of the veins.

Economic Minerals other than Gold.

The Lower Cambrian of the Atlantic coast contains, besides gold, few minerals which can be regarded as of economic value.

Smithfield.

Poole's analyses.

Silver.—Argentiferous galena is found in small quantity in many auriferous quartz-veins, especially when these are in close proximity to granite masses, as at Goldenville, Crow's Nest and Salmon River; and the gold usually contains a small percentage of silver. But the only place where galena was found in large quantity is at Smithfield, on the south bank of the West River of St. Mary's, two miles west of Glenelg, where it occurs in small veins cutting the narrow belt of quartzite left between the granite of the south-side of the river and the overlying Carboniferous conglomerate. Mr. Henry S. Poole* gives the following results of two analyses of this ore:—

	No. 1	No. 2
Lead	86·12	86·02
†Silver	·044	·049
Iron	·07	·02
Copper	·03	·03
Zinc	absent.	absent.
Arsenic	mere traces.	mere traces.
Antimony	mere traces.	mere traces.
Sulphur	13·32	13·30
Lime	trace.	trace.
Magnesia	trace.	·18
Silica (sand)	·426	·402
Moisture	trace.	trace.
	100·00	100·00
†Equal to per ton	15·75 oz.	17·75 oz.

Mr. Howard Clark prospected this locality some years ago, and took out several tons of the ore; but nothing has been done since 1884. In various places along the northern boundary of the Lower Cambrian rocks between Melrose and Smithfield, the crushed slate already referred to has also been mined, but only minute traces of galena have so far been discovered.

Canso.

Copper Ore.—Copper pyrites is generally found associated with arsenical pyrites and other minerals in the auriferous lodes as, for example, on the south side of the Canso road, half a mile east of its junction with the Whitehaven road, on the farm of Mr. John Reynolds. Here it occurs in a vein composed of quartz and granite and already mentioned in the description of the first granite area. Both the quartz and granite, which are intimately mixed, contain yellow and horse-flesh copper ore, iron-pyrites, mispickel and green clay. It was opened in 1881 and 1882 by means of cross trenches, but abandoned.

* Report of the Department of Mines of Nova Scotia for 1875, p. 63.

Arsenical Pyrites.—Massive and crystalline arsenical pyrites is often associated with quartz in wide veins near the granite masses. On the north side of the Sherbrooke district, a vein four or five feet wide, mostly composed of massive mispickel, contains also, no doubt, a large quantity of gold. Sherbrooke.

Iron Ore.—Some of the layers of the upper graphitic slate contain a considerable quantity of magnetite and hæmatite. I was informed by a land surveyor that, while engaged in surveying some lines at the head of the Slate Rock Brook on the east branch of Liscomb River, exactly where the upper slate band crosses the brook, he found the magnetic needle of his compass greatly affected. The rocks of this band were also noticed to be in that vicinity particularly charged with iron ore. Liscomb River.

Building-stone, Bricks, etc.—The adaptability of the granite for building purposes has already been mentioned. The fine red granite at the Ogden school-house, as well as some fine-grained, reddish-gray and gray varieties, are susceptible of a beautiful polish. The Whitehaven granite has also been used for millstones, and several ship-loads were, some years ago, taken for this purpose from Millstone Island. Red granite. Millstones.

Some of the bluish-black layers of the upper graphitic slate, are known to make excellent whetstones, and a quantity of this slate from St. Mary's Bay, one mile and a half below Sherbrooke, sent to the United States, is said to have been well appreciated. Whetstones.

At Stillwater, good sand, and clay suitable for brick-making, occur along the banks of the river, but the demand here is so limited that very few bricks have been made. Bricks.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

NOTES TO ACCOMPANY A GEOLOGICAL MAP

OF THE

NORTHERN PORTION

OF THE

DOMINION OF CANADA,

EAST OF THE ROCKY MOUNTAINS.

BY

GEORGE M. DAWSON, D.S., F.G.S.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1887.

To ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to present herewith a geological sketch-map of the northern portion of the Dominion of Canada, with accompanying systematized notes. These may be considered as supplementary to the Geological Map and Sketch of the Physical Geography and Geology of the southern portion of Canada, published under your direction in 1884.

I have the honour to be,

Sir,

Your obedient servant,

GEORGE M. DAWSON.

OTTAWA, January 1, 1887.

NOTES TO ACCOMPANY A GEOLOGICAL MAP

OF THE

NORTHERN PORTION

OF THE

DOMINION OF CANADA,

EAST OF THE ROCKY MOUNTAINS.

The geological map of the northern part of the Dominion of Canada, which these notes are intended to accompany, is little more than a systematic compilation from all available sources, in which the observations of others have been interpreted, as far as possible on a uniform plan, and with special reference to Canadian analogies. It is designed primarily as a supplement to the general geological map of the southern portion of the Dominion, published by the Geological Survey in 1884, for the compilation of the western part of which, the writer was largely responsible. While, however, the facts embodied in the map of 1884 are chiefly the direct result of the explorations of the Survey, these explorations have as yet scarcely touched upon the northern region covered by the present map. In consequence of this fact, these explanatory notes have necessarily assumed a different form from those embodied in the 'Sketch' published with the map of 1884. The sources from which the principal facts for the present map have been derived, are stated at greater length in these notes, which it has been deemed advisable to publish in consequence of the scattered character of the information, distributed as it is through a very considerable number of works, some of which are not readily accessible. It is hoped that these notes may serve to outline the more important observations on which the provisional geological mapping of this great northern region of the continent depends, with sufficient completeness to obviate, in most cases, the necessity of reference to the original works, and to form a summarized account of the formations, which will be of service to the traveller and explorer, and serve as a basis Character and design of map and notes.

References. for subsequent additions and corrections. I have been careful in all cases, however, to give detailed references to the original authorities, not only for the purpose of doing justice to the many workers in this field, but also to facilitate further study, when such may be desired. I may add, that while great caution is essential in correlating the notes afforded by different travellers, and it is often necessary to reject uncertain observations,—particularly such as have occurred from a failure to distinguish between erratics and rocks in place,—it is a matter of surprise how great a number of valuable facts has been accumulated, largely, by observers comparatively untrained in geological work, and sometimes travelling under circumstances of great difficulty and privation. These remarks refer particularly to the extreme northern part of the region.

Character and extent of information.

Palæontology. While allusion is made in these pages to the palæontological results so far obtained in this northern region, no attempt is made to embody complete or critical lists of the fossils, for which the authorities quoted must be consulted. It may be added, that the list of works given at the end of these notes is not intended to be a complete bibliography of the geology of the region. It includes only those works to which actual reference has been made in the course of the compilation, and from which facts of greater or less importance have been derived, no mention being made of a large number of publications, which have been carefully examined, but from which no geological information of service could be gleaned.

List of authors.

Acknowledgment of assistance. I have to acknowledge my indebtedness to a number of gentlemen, who have kindly assisted me in the effort to make the map as complete as possible, by answering enquiries addressed to them on various subjects, particularly to Dr. John Rae, Prof. S. Haughton, Capt. A. W. Greely, Lieut. D. L. Brainard, Baron A. G. Nordenskiöld, Prof. G. C. Laube, Prof. Jules Marcou, Prof. K. I. V. Steenstrup and Dr. Franz Boas. Sir Wm Dawson has also communicated the result of examinations of rock specimens obtained by various Arctic expeditions, and now preserved in museums in London, with special reference to their analogy with the rocks of the better known parts of the Dominion of Canada.

Archæan rocks. A glance at the map will show that the Archæan or Eozoic rocks are dominant in the northern part of the continent. They form also, so far as has been ascertained, the greater part of Greenland, and doubtless underlie, at no great depth, the entire Arctic Archipelago. While the information available is sufficient to indicate the existence of the different subdivisions of the Archæan which are met with in the southern portion of Canada, including the lowest Laurentian or granitoid gneiss series, the Middle Laurentian, possibly the peculiar rocks classed as the "Upper

Laurentian and Huronian.

Laurentian," and certainly of the more schistose and generally darker coloured and more basic rocks classed as Huronian, it is far too imperfect to admit of the separation of these subdivisions on the map. It is evident that the Huronian is represented in parts of the west coast of Greenland, and it is probably also recognisable on the Labrador coast, and on the west coast of Hudson Bay, and possible that it is elsewhere present over the Archæan area, in proportions as great as it has been found to hold where these rocks have been subjected to more systematic and detailed investigation. The distribution of tho Huronian is important from an economic point of view, on account of its generally metalliferous character, which may eventually give value to tracts of country in which the rigorous nature of the climate entirely precludes the possibility of agriculture. Huronian.

The occurrence of well stratified orthoclase-gneisses with mica-schists and crystalline limestones, with which are associated graphite, magnetite and other well known minerals of the Middle Laurentian of parts of Ontario and Quebec, appears to indicate the probable repetition of the conditions of occurrence of the commercially valuable deposits of graphite, apatite, etc., of the St. Lawrence region. The discovery of cryolite and tin-stone in Greenland, in rocks which are evidently Laurentian (though it is impossible to decide whether they should be referred to the middle or lower portion of the system), constitutes an additional claim to attention in these fundamental strata in the north. Middle Laurentian.

The southern part of Baffin Land, including Frobisher Bay and Cumberland Sound, together with Melville Peninsula, may be particularly referred to as evidently exhibiting a considerable development of Middle Laurentian rocks.

It should be explained, that in colouring the great Archæan region of the northern part of the continent, it has been found necessary to assume the continuity of the area of those rocks, where facts to the contrary are not known. While our present knowledge does not allow us to question their occurrence over the area so coloured, and the lines of observation so far carried into the region lead to the belief in its homogeneously Archæan character, it is quite possible that additional outliers of Cambrian rocks, like those of the Coppermine or of Mistassini Lake, may exist in the western and eastern parts of the Archæan area, respectively, while in the vicinity of the Arctic coast it is probable that many additional patches of the flat-lying limestone series will eventually be found. Method adopted in defining Archæan.

While the term Cambrian, as applied on the accompaning map, may be interpreted in the widest sense, namely, as including all rocks above the Huronian, to the base of the Cambro-Silurian of the Cana- Cambrian.

dian Geological Survey, and the reference of the rocks of the region here treated of to the Cambrian is based entirely on lithological and stratigraphical grounds, the rocks so classed are, as far as known, probably referable to the Lower Cambrian. It is further quite evident, that in the extensive area coloured as Cambrian on the Arctic coast, in the vicinity of the Coppermine River, the rocks are analagous in character to those of the Keewenaw or Animikie of the Lake Superior region, and probably represent both groups of that great copper-bearing series. The mere occurrence of native copper in considerable quantities on the Coppermine, in association with prehnite and other minerals resembling those which accompany it on Lake Superior, gives a *prima facie* probability to this correlation, which is borne out by a more careful study of Sir J. Richardson's accurate notes, and was recognised by Richardson himself, who had examined both regions. Prof. R. D. Irving states that the Animikie of Hunt or "Lower Group" of Logan, on Lake Superior, is composed of a great thickness of quartzites, quartz-slates, argillaceous, or clay-slates, magnetic quartzites and sandstones, thin limestone beds, and beds of a cherty or jaspery material, associated with coarse gabbro and fine-grained diabase (Copper Bearing Rocks of Lake Superior, 1883, p. 379), while the overlying Keewenaw series is made up of similar basic crystalline rocks, with interbedded detrital rocks, chiefly reddish conglomerates and sandstones, the conglomerates consisting for the most part of pebbles of acidic crystalline rocks (pp. 27-29). A comparison of the above description with that of Richardson of the rocks of the Coppermine, subsequently quoted, will show the practical lithological identity of the two widely separated areas.

Keewenaw and Animikie rocks.

Distinctive characters of these rocks.

Other Northern representatives of these rocks.

Though not a geologist, Captain Back, who had seen the Coppermine rocks, referred the formation coloured as Cambrian on Great Slave Lake to the same series, from its lithological similarity; to which also the doubtfully placed area of Cambrian on Back's route from Great Slave Lake to the mouth of Great Fish River is attributed. To this formation also may be referred the great volcanic series, described by Dr. R. Bell as the Manitounuck group, of the east coast of Hudson Bay, south of the limit of the map, and the red sandstones of his "Intermediate group," which he regards as unconformably underlying the Manitounuck rocks, may possibly also belong to the Keeweenaw or Animikie.

Importance of the Cambrian.

Throughout the whole of the vast northern part of the continent, this characteristic Cambrian formation, composed largely of volcanic rocks, apparently occupies the same unconformable position with regard to the underlying Laurentian and Huronian systems. Its present remnants serve to indicate the position of some of the earliest geological basins,

which, from the attitude of the rocks, appear to have undergone comparatively little subsequent disturbance. Its extent entitles it to be recognized as one of the most important geological features of North America.

Areas doubtfully classed as Cambrian.

The area coloured as Cambrian to the west of the Mackenzie must be considered as very doubtful. While it does not show, so far as known, trappean rocks like those of the Coppermine, it must be remembered that volcanic conditions are necessarily not universal at any particular period, and that while Cambrian rocks, (probably in great part referable to the Lower Cambrian,) are extensively developed further south in the Rocky Mountain Range, though they often include interbedded trappean flows, these become quite subordinate. (Annual Report Geol. Survey of Can., 1885, p. 157 B.)

In the entire absence of palæontological evidence, the Cape Rawson beds of Grinnell Land are also provisionally referred to the Cambrian, on account not only of their lithological resemblance to the rocks of the Animikie (as gathered from the description of Messrs. Fielden and De Rance and sustained by the opinion of Sir Wm. Dawson, based on an examination of the specimens brought back), but also on their similarity as a whole to the Nova Scotian gold-bearing series, as pointed out by the authors first referred to. * Lithologically, their resemblance is not close either to the typical Huronian of Sir W. E. Logan or to the rocks elsewhere classed as Huronian, which have been provisionally named Keewatin in a report by Mr. A. C. Lawson (Annual Report Geol. Survey of Can., 1885). Neither do they correspond in character to the rocks which have been described as occurring with the Laurentian in southern Greenland and are believed to represent the Huronian in that region.

Silurian and Cambro-Silurian.

The quotations given in a subsequent page from Prof. S. Haughton's admirable paper on the Arctic Archipelago, present the main facts with regard to the character of the Silurian and Cambro-Silurian (Upper and Lower Silurian) rocks. It need here only be added that these are chiefly pale limestones, often of a yellowish or cream colour and frequently more or less dolomitic. They rest everywhere unconformably on the Archæan or on the Cambrian rocks, and one of their most constant features appears to be the existence of a zone of red sandstones or arenaceous limestones and conglomerates at the base, (*Cf.* p. 44 R) a fact which leads me to suspect that the red sandstones of Tunnudleorbick and Igalliko in Greenland, which have been doubt-

* Messrs. Fielden and De Rance refer the Cape Rawson beds to the Huronian on the assumption that the gold-bearing series of Nova Scotia is of that age, but these Nova Scotian rocks now appear to be more appropriately assigned to the Lower Cambrian.

fully referred on lithological grounds to the Permian, Devonian and Cambrian, may very probably also belong in reality to the Silurian.*

Their undisturbed condition.

This great Silurian and Cambro-Silurian limestone series is very widely developed, and is in most places nearly horizonal and undisturbed, with long light undulations in the bedding or persistent and uniform dips at very low angles. These features are very prominently shown in the sketches of many parts of the coast-line in the Arctic islands, reproduced in the volumes of voyagers. But for the undisturbed and flat condition of the limestones and the formations overlying them in the Arctic basin, it would be impossible, with the fragmentary geological information available, to offer any proximately correct geological map of the region as a whole.

Supposed Cambro-Silurian Arctic land.

In a paper printed in the report of the British Association for 1855, J. W. Salter states that the Silurian fossils, obtained up to that time, showed an uniform horizon of Upper Silurian limestone stretching from near the entrance of Barrow Strait to Melville Island and far to the south along Prince-Regent Inlet, and argues therefrom a wide extent of circumpolar land in Lower Silurian (Cambro-Silurian) times. In this he was followed, two years later, by Sir R. Murchison, who writes:—"I am led to believe that the oldest fossiliferous rock of the Arctic regions is the Upper Silurian." (Appendix to M'Clure's voyage, p. 402, Siluria, p. 440). Though the Upper Silurian beds undoubtedly occupy a great part of the American polar region, characterizing the "South of North Devon and nearly all the islands south of Melville and Lancaster sounds, including the south of Banks Land, Prince-of-Wales Land, King-William Land, North Somerset, Boothia Felix, etc." (Fielden and De Rance. Quart. Journ. Geol. Soc., vol. xxxiv.) the occurrence of Lower Silurian (Utica) fossils in Frobisher Bay, as shown by Hall's collections, on the shores of Kennedy Channel, as determined by Etheridge, and the occasional discovery of Lower Silurian forms in the regions above referred in a general way to the Upper Silurian, prove that the generalization made by Salter and Murchison, on the evidence of less complete collections, cannot now be admitted, and that the limestones of the Arctic represent probably the whole of the Silurian and possibly part of the Devonian. (See Fielden and De Rance *loc. cit.*) Heer enumerates the following places, besides those above particularly referred to, as yielding Lower Silurian types:—North Devon, Cornwallis Island, Griffith Island, west coast of King-William Land, Boothia (Flora Fossilis Arctica, vol. i, p. 24).

Subsequent discovery of Cambro-Silurian fossils.

* See Pingel, Om den af Porphyrgangue gjennembrudte röde Sandsteen i det sydige Grönland, Kjobenhavn 1843. Laube Sitzungsberichte der K. akad. der Wissenschaften, Wein. lxviii band, 1873. "Arctic Manual," foot notes pp. 497, 541. I have not seen Pingel's paper, which is referred to by De Rance in his article in Nature. Prof. Marcou informs me that Komerup writes of these rocks that they can scarcely be named Permian, their age requiring verification. Meddelelser om Grönland, Kjobenharn, 3, p, 227, 1880.

Devonian limestones.

The above allusion to the possibly Devonian age of part of the limestones of the Arctic basin proper, is of interest in connection with the question of the relation of these limestones to the equally importan- limestone series of the Mackenzie River region. The early reference of an extensive portion of these latter to the Silurian by Isbister and others, can scarcely now be maintained, since Meek, as the result of his examination of the most ample collection of fossils which has ever been brought together from the Mackenzie valley, reports the existence, in the limestones, of Devonian forms alone, though, as he cautiously remarks, he is not prepared to deny the existence of Silurian rocks. This Devonian facies is maintained by the limestones of the Mackenzie valley to the very shores of the Arctic sea, as shown by the occurrence of Hamilton group fossils on the Anderson River, noted on a subsequent page.

Relations of Silurian and Devonian limestone series.

In endeavouring to correlate these Devonian limestones of the Mackenzie with the rocks to the east and north, the question arises whether they are represented by the "Silurian" limestones, or the sandstones referred by Heer to his "Ursa Stage," which overlie these in the Arctic basin. The distribution of the rocks, when examined on the map, is altogether in favour of the first stated hypothesis, which on a careful consideration of the available facts, I am inclined to consider as the correct one. The question cannot here be discussed at length, but it may be noted that the lithological character of much of the limestone of the two districts is very similar, extending even to the occurrence of beds of gypsum in both regions, while the few and very imperfect fossil plants (for the most part species not elsewhere known) described by Heer from the beds of the "Ursa Stage" of Melville Island and vicinity, may without any impropriety be assigned to the Lower Carboniferous. It would appear, indeed, that we must, for the present at least, regard the widely spread limestone formation which borders and rests upon the Laurentian from the vicinity of Lake Winnipeg to the mouth of the Mackenzie and thence to Baffin Bay and Grinnell Land, as representing a single great series. On Winnipeg and Manitoba lakes and in their vicinity, the rocks of this series have yielded fossils ranging from the Cambro-Silurian to the Devonian. In the Mackenzie valley, the Devonian limestones seem to have so far overlapped the Laurentian plateau that no distinctively Silurian beds appear, or at least none have as yet been recognized, while in the Arctic basin, the conditions found about Winnipeg Lake are again repeated. A thorough comparison and revision from a palæontological point of view, of the fossils from the Mackenzie and the Arctic basin, in the light of all the facts now known, would, however, possess great importance and interest.

Great middle Palæozoic limestone formation.

The discovery by Nares' expedition of fossils of a distinctively

Devonian character on the northern shore of Grinnell Land, is subsequently referred to.

"Ursa Stage" and Carboniferious limestones.

Allusion has already been made to the beds of the so-called Ursa Stage of the Arctic Archipelago, and their character, as described by Prof. Haughton from an examination of the specimens brought back, is noted on a subsequent page. This formation, which both from its extent, and in its character as a coal-bearing series is a very important one, is coloured on the accompanying map as Lower Carboniferous.

The main facts connected with the Carboniferous limestones, and with the still later rocks found in places to overlie these, are also referred to in the sequel and need not here be entered into in detail. It may be noted, however, that so far as I am aware, we are without any estimate of the entire thickness of these or the previously mentioned rock-series of the Arctic basin.

Lias or Trias.

Certain small outlying areas in the northern part of the Arctic Archipelago have been referred to the Lias. These it appeared possible might now be assigned to the "Alpine Trias," a formation which since the above reference was made has been found to be wide-spread and important in the Cordillera region of North America, as far north as the northern part of British Columbia, and is also characteristically developed in Spitzbergen and the North-west of Siberia.* This question was referred to Prof. S. Haughton, who had originally described the fossils on which the age of the beds in question had been determined. The result of a critical re-examination of the fossils, which Prof. Haughton was so kind as to have made, appears, however, rather to confirm the original Liassic or Jurassic reference of these northern rocks. (*Cf.* p. 49 R.)

Laramie and Miocene.

Respecting the so-called Miocene of the Mackenzie River, and its probable identity with the Laramie of the West, some notes will be found on a later page. Had the facts in our possession been sufficient to admit of the separation of the "Miocene" of this region from the Cretaceous, it would have been given the same colour on the map with the "Miocene" of Banks Land, Greenland and Grinnell Land. The so-called Miocene of the two last mentioned localities is now regarded as equivalent to the Laramie, or at least not newer than Eocene, by Mr. J. Starkie Gardiner, Sir Wm. Dawson and other palæobotanists.† Our knowledge of the flora of the Banks Land beds is very slight, being confined to that of the structure of a few specimens of fossil

*Cf. Mojsisovics. Vorlage des Werkes "Arktische Triasfaunen," Verhandlungen der K. K. Geologischen Reichsanstalt, Nr. 7, 1886.

† Cf. Trans. Royal Soc. Can., vol, i., p. 31. Nature, vols. xix., p. 124, xx. p. 10. Also on the homogeniety of the Arctic "Miocene" Heer's Flora Fossilis Arctica and "Arctic Manual," p. 368 *et seq.*

woods, subsequently mentioned, which have been reported on by Dr. C. Cramer, but, so far as it goes, it presents no features incompatible with the possible Laramie age of these deposits also. It should be noted that the associated volcanic rocks of Disko and vicinity are included on the map as "Miocene," and that the area similarly coloured on the Greenland coast, north of Melville Bay and east of Smith's Sound, is so denoted chiefly because of the occurrence of horizontal or nearly horizontal trap beds, which are described by Dr. Sutherland as characteristic of this coast. (*Cf.* 55 R.)

Superficial deposits. No attempt is here made to incorporate the very numerous and important observations which have been accumulated on the superficial deposits of the glacial period in the region covered by the map. These would require separate treatment, and the information necessary for their definition on a geological map is almost altogether wanting. A few facts bearing on the direction of glaciation are, however, appended to these notes.

Arrangement of notes. A regional arrangement is adopted for the following notes in preference to one according to age of the rock-series, the latter having been found unsuitable, both on account of the disconnected character of much of the information and the great area involved.

Economic minerals. Special care has been taken to include all authentic notes which have been met with in the various works referred to on minerals of economic value.

MACKENZIE RIVER REGION.

Observations of Sir J. Richardson. Our knowledge of the geological features of the Mackenzie River and its vicinity, is chiefly due to Sir John Richardson, whose observations on it are remarkably precise and satisfactory, considering the difficulties under which they were frequently made and the rapidity with which he was obliged to travel through this region on his several journeys. These observations are, for the most part, recorded in the following works:—Sir J. Franklin's Narrative of a Journey to the Polar Sea, 1819–22, Narrative of a Second Expedition to the Shores of the Polar Sea, 1825–27, and in Richardson's Journal of a Boat Voyage through Rupert's Land. These, for the sake of brevity, are referred to in the following pages as '1st Exp.,' '2nd Exp.,' and 'J. B. V.,' respectively, and the facts are arranged in order from south to north, following the course of the river-valley.

Slave River.

Slave River. The portion of the Mackenzie River between Athabasca and Great Slave lakes, is generally named Slave River. In this region, the geological boundaries shown on the accompanying map, have been

laid down after careful comparison of the several notes of Sir J. Richardson and other available authorities, which it is considered unnecessary to quote in detail, though a few isolated facts of special interest may be referred to.

Petroleum deposits.

The district to the south of Athabasca Lake, on the Athabasca River and its tributary the Clearwater, (not included by the accompanying map), and also on Peace River, is characterized by a great abundance of pitch and petroleum deposits and springs. These are described by Sir A. Mackenzie, Sir J. Richardson, Prof. Macoun, Dr. Bell and others (*Cf.* Reports of Progress Geological Survey, 1875–76, p. 169, 1882–84, p. 32, c c). It is interesting to observe the recurrence of such deposits at intervals along the Mackenzie valley to the Arctic Sea.

At the "Lightening Place of the Hummock" on Slave River, thirty miles below Fort Chepewyan, the limestone beds were noted by Richardson to contain mineral pitch in fissures (J. B. V., vol. i, p. 137.)

Salt springs.

About half-way between Athabasca and Great Slave lakes, Salt River joins the Slave River. Of this stream, Richardson writes:— "The Salt River flows in from the westward, a short way below the portages. We ascended it for twenty-two miles, including its windings, but not above half that distance in a straight line, for the purpose of visiting the salt springs from whence it derives its taste and name. Seven or eight copious saline springs issue from the base of a long even ridge about six hundred feet high, and spreading their waters over an extensive clayey plain, deposit a considerable quantity of very pure common salt in large cubical crystals. The *mother water* flowing into the Salt River gives it a very bitter taste, which it retains until near its junction with the Slave River, when the addition of some fresh water streams, renders it only slightly brackish. A few patches of greyish compact gypsum were exposed on the side of the ridge from whence the springs issue." (1st Exp., p. 518.)

Captain Back, who accompanied Richardson, again visited these salt springs in 1833. He writes:—"There were no mounds like those seen in 1820; but just at the foot of the hill which bounds the prairie in that quarter, there were three springs, varying in diameter from four to twelve feet, and producing hillocks of salt, from fourteen to thirty inches in height. The streams were dry, but the surface of the clayey soil was covered, to the extent of a few hundred yards toward the plain, with a white crust of saline particles." (Narrative of the Arctic Land Expedition, p. 80.) Petitot states that, according to the Indians, the Caribou Mountains, between Salt River and the Peace River, contain much rock salt. (Bul. Soc. Géog., Paris, vol. x, p. 140.)

Great Slave Lake.

Richardson describes the west shore of this great body of water as composed of horizontal strata of limestone, forming a flat country (2nd Exp., appendix p. xxiv.) In his Journal of a Boat Voyage (vol. i, p. 152,) he writes:—"In the vicinty of the westernmost channel of the delta [of Slave River] and from thence to the eflux of the Mackenzie, the whole western shore of the lake is limestone, associated with a bituminous shale, and belonging, as well as can be ascertained from its fossils, to the Erie division of the New York system, which includes the Marcellus shales." He also refers to the limestone as being bituminous, and speaks of fossil shells of which the cavities are filled with bitumen.

West end of Great Slave Lake.

Prof. F. B. Meek, in a paper published in the first volume of the Transactions of the Chicago Academy of Sciences (1868), describes a number of fossils obtained from seven or eight localities along the Mackenzie between Clearwater River and the Arctic Ocean, and gives a very clear and succinct account of the geology of the river, derived from the works of Richardson and Isbister. The fossils described were collected by Major R. Kennicott, who visited this northern country under the auspices of the Smithsonian Institution, and by Messrs. R. W. McFarlane and B. R. Ross, of the Hudson's Bay Company. Prof. Meek's paper gives by far the most definite information as to the stratigraphical position of the limestone series of the region. He writes thus:—"Amongst all the collections under examination from various localities along Mackenzie River and its tributaries, between Clearwater River and the Arctic Ocean, a distance by the general course of the valley of more than one thousand miles, there are no Carboniferous or characteristic Silurian forms" (p. 76). From a locality near Fort Resolution, on Great Slave Lake near the mouth of Slave River, he notes *Favosites polymorpha*, *Atrypa reticularis*, a small smooth *Spirifer* (*Martinia*), *Cyrtina Hamiltonensis*, a *Chonetes*, a *Productus*, a *Lingula* and a *Proetus*. These fossils were obtained from a highly bituminous limestone, and are regarded as Devonian and probably of nearly the horizon of the Hamilton group. They resemble those of the Clearwater (p. 68). These fossils serve to fix the age of the horizontal limestone formation of the west end of Great Slave Lake, though Meek states (as previously noted) that he is not prepared to deny the existence of Silurian beds also, as represented on Isbister's map.

Prof. Meek on Devonian of Mackenzie.

At the extremity of the long northern arm of Great Slave Lake, Richardson notes "clay-slate" as occurring at one place (1st Exp. p. 520), while Petitot, on his map, indicates limestone as forming the east

North arm of lake and west boundary of Archæan.

side of the entrance to this arm. Richardson, however, elsewhere states very definitely that the eastern side of this arm is occupied by "primitive rocks," and shows the same feature on his map, (J. B. V., vol. i., p. 147). He writes—"In 1820, when we crossed Great Slave Lake, near the 113th meridian, we traced the western boundry of these [primitive] rocks, from near the mouth of Slave River, northwards by the Reindeer Islands to the north side of the lake, and continued to travel within their limits up to Point Lake in the 66th parallel." In reverting to the same subject, (J. B. V., vol. ii., p. 200), he states that the western border of the "primitive rocks" runs "across the outlet of Athabasca Lake to the deep, northern arm of Great Slave Lake, and onwards by Marten Lake, across the two eastern arms of Great Bear Lake, to the Copper Mountains." The indications thus given are confirmed by the notes on Petitot's map, in so far as the region between Great Slave and Great Bear lakes is concerned.

Dr. R. Bell notes red conglomerate and fine-grained grey and green quartzites as collected by Capt. H. P. Dawson, R.A., on the northern arm of the lake (Trans. Royal Soc., Can. vol. ii.), from which it may be inferred that other formations, beside those above mentioned as characteristic, occur in this vicinity. Capt. Dawson also obtained specimens of specular iron in the same district (Report Second Hudson's Bay Expedition, p. 66).

Western part of Great Slave Lake.

Capt. Back's description and specimens (Arctic Land Expedition, p. 544, *et seq*), show that the north side of Great Slave Lake, from the entrance of the north arm westward, consists of Laurentian rocks. The hills are said to be rocky, low, grey and rounded, and gneiss, porphyry and granite are the prevalent materials. The large islands and promontory which occupy the centre of the eastern part of the lake are, on the contrary, "of the trap formation" and exhibit long lines of high mural precipices, sometimes distinctly columnar. Back compares these to those formerly seen by him near the Coppermine, and refers them to the same formation. Near the western end of the long island, Peth-the-nu-eh, he says the Indians obtain greenish-grey "marl" of which they make their pipes. The same point is shown by Petitot, as composed of black serpentine, which he also notes is used for the manufacture of pipes, (Bul. Soc. Géog., Paris, vol. x., p. 143). Specimens of slaty magnesian limestone were obtained by Back from the south side of the long island. Similar limestone is associated with the series of the Coppermine River, and there is every reason to believe that the trap formation here should be referred to the same great Lower Cambrian series.

Pebbles of a jasper conglomerate, which evidently exactly resembles the jasper conglomerates of Lake Huron, were collected near the

east end of the lake. The rock was, however, not seen in place. (Arctic Land Expedition, p. 547).

Mackenzie River from Great Slave Lake to Bear Lake River.

Devonian and Cretaceous rocks. In the appendix to Franklin's Second Journey, Richardson writes:—"The only rocks seen *in situ* between Slave Lake and The Forks [mouth of the Liard] were a bituminous shale of a brownish-black colour, in thin slates, and a slate-clay of a pure yellowish-grey colour, which, as well as the bituminous shale, forms steep banks." (appendix p. xxiv). In his subsequent Journal of a Boat Voyage, (vol. i., p. 164), he describes on the same part of the river, "bituminous shale" and "greyish-green slate-clay," which weathers into a tenaceous clay, and adds:—"The whole banks of the river seem to belong to a shale formation; but from the want of induration of the beds, they have crumbled into a slope more or less steep." Though *Tentaculites fissurella* is noted as occurring in the bituminous shale, it appears probable that the general surface of the country in this vicinity is composed of Cretaceous or Laramie beds, through which the river has cut in some places to the subjacent Devonian rocks.

Liard River. Richardson did not ascend the Liard River in any of his journeys, but learned that, "for twenty-four miles upward from its mouth, it flows through sand and shale, with limestone occasionally cropping out," while seventy-five miles up it is a high hill, named the "Noh-'hanne Butte," on the summit of which is a salt spring. From this hill, Mr. McPherson brought specimens of limestone, "similar in lithological character to those procured from the Rock by the River's Side." (J. B. V., vol. ii. p. 203). This observation may be regarded as approximately fixing the western edge of the Cretaceous and Laramie rocks in this latitude, while the limestone seen further down the Liard, may be that underlying these rocks, exposed by the river in places. In loose fragments of limestone at the mouth of the Liard, Kennicott collected fossils which, according to Meek, are referable to the Hamilton group. (Trans. Chicago Acad. Sci., vol. i., p. 69).

Neighbouring part of Rocky Mountains. The Rocky Mountains, where approached by the Mackenzie below the mouth of the Liard, are described as consisting of a number of ridges running S.S.W., or S.W. by S., with abrupt eastern faces and longer slopes to the westward, thus corresponding with the outer ridges of the same range much farther south, and probably indicating a similar prevalent westward dip. A few specimens obtained from this part of the range are not sufficiently characteristic to be of much value, but some of them, from near the Liard River, are said to be indistinguishable from those

of Limestone Point, in Great Bear Lake, noted further on. (2nd Exp., appendix, p. xxvi). Specimens of plumbago and specular iron were also given to Richardson as derived from this part of the mountains. (p. xxv).

Graphite and iron ore.

The Rock by the River's Side.

The "Rock by the River's Side" on the east bank of the Mackenzie, about half-way from the Liard to Bear Lake River, is the only solid rock observed by Richardson in this part of the course of the river. It consists of limestone dipping at high angles and is cut by veins of gypsum. The rocks are said to be like those of the limestone ridge at the rapid on Bear Lake River (2nd Exp., appendix p. xxx.) Shale beds are said to "abut" against the lower side of the rock (J. B. V., vol. i., p. 183) rendering it probable that there is here an unconformable contact of the Cretaceous rocks with the limestones.

Relation of valley to the Rocky Mountains.

In a general account of the features of this portion of the valley (J. B. V., vol. i., p. 171). Richardson describes the river as passing to the west of the first or eastern ridge of the Rocky Mountain system at "The Bend," some distance below the mouth of the Liard. This first range is seen further on, at intervals, to the eastward, running toward McVicker Bay, of Great Bear Lake. After flowing in the valley between the first and second ridges for upwards of fifty miles, the river again turns to the westward and crosses the second ridge, the "Rock by the River's Side" being part of this ridge, which runs toward the promontary between Keith and McVicker bays on Great Bear Lake. It would appear that low flanking ridges parallel to the limestone ranges of the mountains are here separated by areas of Cretaceous or Laramie rocks, which occupy the valleys.

Cretaceous and Laramie.

The valley of the Mackenzie near the mouth of Bear Lake River, is occupied by rocks referred by Richardson to the "Lignite formation," which, with little doubt, represent the series now known as the Laramie. The formation "may be characterized as consisting of wood-coal in various states, alternating with beds of pipe-clay, potter's clay, which is sometimes bituminous, and slate-clay, gravel, sand and friable sandstones, and occasionally with porcelain earth. The strata are generally horizontal, and as many as four beds of lignite are exposed in some parts." (2nd Exp., appendix p. xvii.) The lignites were observed to be on fire in various places, both by Sir A. Mackenzie, in 1789, by Richardson and others. Four sections seen in the banks of the river are detailed by Richardson—(1) at the mouth of Bear Lake River, (2) five miles above the mouth of the river, and (3) ten miles above the same point (2nd Exp., appendix pp. xix-xxi.) A detailed description of these beds and the lignites they contain is again given in the Journal of a Boat Voyage, and fossil plants obtained from the shales are figured (vol. i., p. 186.)

Fossil plants collected from the same vicinity are also described and figured by Prof. O. Heer in his Flora Fossilis Arctica (vols. i. and vi.) He describes them as Miocene, though they correspond with those of the Laramie of North America, not now regarded as Miocene. (*Cf.* Geology and Resources of the 49th Parallel. Appendix by Sir Wm. Dawson and Trans. Royal Soc. Can. vol. i., Sect. iv., p. 31.)

Great Bear Lake and Vicinity.

The following notes are chiefly derived from Sir J. Richardson's appendix to the narrative of Sir J. Franklin's second expedition (1825-27.)

The rocks of the south-east extremity of McTavish Bay (the south-eastern arm of the lake) are described as red granites and gneisses, forming dome-shaped hills 800 to 1000 feet in height. The shores of the point between this bay and McVicker Bay are said by Richardson to be low, and his observations taken in conjunction with those of Petitot,—who shows the promontary between McVicker and Keith bays as composed of limestone,—appear to indicate that the point above referred to may be regarded as also underlain by the same rock. McTavish Bay.

At the mouth of Dease River, at the north-east extremity of the lake, Richardson describes the occurrence of hills composed of purplish dolomite in horizontal strata. The brief notes given on these rocks, (p. v), seem to show that a small Cambrian outlier may exist here, though the prevailing formation of the district is evidently Laurentian. Mouth of Dease River.

At Limestone Point, on the north shore of the lake, twenty miles from Dease River, a low range of hills terminates on the border of the lake in cliffs composed ot light-coloured dolomite, interstratified with a material which is called (with a mark of interrogation), "earthy greenstone." The beds dip north-north-west at a high angle. These again might be referred to the Cambrian, but on consideration of the facts, I am disposed to regard them as more probably belonging to the Devonian or Silurian limestone series, elsewhere so widely spread in this region. Limestone Point.

The greater part of the north-western and western shores of Great Bear Lake, together with the low land at the base of Great Bear Mountain, which stands on the promontary to the south, appear, according to Richardson's notes, to be formed of rocks referable to the Cretaceous or Laramie. He describes slate-clay and shale more or less bituminous, plastic and bituminous coal and earthy clay, with selenite, pyrites, poor clay-ironstone and efflorescenses of alum and Laramie rocks.

sulphur. At the base of Great Bear Mountain, are bituminous slate and slate-clay, holding brown coal. The indications on Petitot's map, however, show that limestone and granite project through the newer formations in places, forming the hills in the centre of the promontory on the west shore of the lake, as well as Great Bear Mountain.

Boulders. An enumeration of boulders seen about Fort Franklin, near the outlet of the lake, is given, and it is stated that they have been probably derived from the east or north-east.

Fort Franklin. At Fort Franklin, bluish slate-clay, probably Cretaceous, occurs. The low, uniform character of the country to the north of this place, and other remarks made by Richardson, afford reason for the belief that similar rocks here probably occupy a tract of considerable breadth, both along the shore of the lake, and on Bear Lake River.

Bear Lake River. The limestone formation is described as occurring at one place on the banks of Bear Lake River, at the rapid. It there "forms part of a ridge, which is continued through the country, on both sides of the river, (p. xii). The dip is said to be south-west, though the ridge, as a whole, is stated to have an anticlinal structure, in the Journal of a Boat Voyage, (vol. i., p. 97), and gypsum is associated with the limestone.

Other rocks described on Bear Lake River must be assigned to the Cretaceous, or possibly in part to the Laramie. At the mouth of the river, however, rocks, both of the limestone series and the Cretaceous, evidently occur, the former probably constituting a projecting ridge. A hill is described on the north bank of the river, at its mouth, composed of limestone rocks similar to those of the ridge at the rapid above referred to. Parts of the limestone are saturated with petroleum, and petroleum springs were observed by Franklin.

Cretaceous fossils. In Prof. H. Y. Hind's Assinniboine and Saskatchewan Exploring Expedition, two species of ammonites are described by Meek, and said to come from Mackenzie River. In his paper in the Transactions of the Chicago Academy of Sciences, previously quoted, Meek refers these more definitely to the neighborhood of the Bear Lake River. In the collections reported on in this paper, he further notes the existence of fragments of an *Ammonite* and an *Inoceramus* from the same vicinity, and adds:—"It is highly probable that these strata belong to the Cretaceous system, though some of the upper portions may be of Tertiary age." (p. 72).

Salt. On Bear Lake River, a little below the rapid, a small stream flows in from the southward, near the sources of which the Indians procure an excellent common salt, which is deposited from springs by natural evaporation (1st Exp., appendix p. xiii.)

Mackenzie River and vicinity below Bear Lake River.

Great Rapid of the Mackenzie.

The "Great Rapid of the Mackenzie" is situated about a hundred miles below the mouth of Bear Lake River. The Mackenzie here appears to break though another of the ridges flanking the Rocky Mountain system, there being a hill on each bank. The hill to the east, Richardson found to be composed of limestones like those elsewhere represented in the district. It is unnecessary to quote his particular description of the rocks given in the appendix (p. xxxiii.)

The sandstones and other softer rocks which appear in and characterize the banks of the river above this place, resume immediately below the rapid, and further on hold ironstone concretions and weather to columnar forms. Abount forty miles lower down, however, the river flows through a narrow defile, the banks of which are described as consisting of limestone in highly inclined strata. This place is named the "Second Rapid" by Sir A. Mackenzie, and "The Ramparts" by the traders.

The Ramparts.

Meek describes fossils collected by Kennicott at The Ramparts with others obtained by Mr. McFarlane forty miles lower on the river, as Devonian, and most probably of about the horizon of the Hamilton group. Those from The Ramparts include:—"A coral having the external appearance of *Amplexus*, but differing in its internal structure, *Favosites polymorpha*, a massive species of *Alveolites*, a *Zaphrentis* (*Z. recta* of this paper) *Atrypa reticularis*, *A. aspera*, a *Rensselaeria ?*, *Cyrtina Hamiltonensis*, and a small *Spirifer* (*Martinia*)" (*Op. cit*, p. 73.) From the second locality, the same corals were obtained, together with *Atrypa reticularis*, a *Rhynchonella*, *Orthis Macfarlanei*, *Spirifer* (*Martinia*) *Franklinii*, and *Gyroceras Logani* (p. 74.)

Both Devonian and Cretaceous shales present.

In the geological notes given by Richardson on this part of the river, both in his appendix to Franklin's second expedition and in his subsequent Journal of a Boat Voyage, the distinction does not seem to be clearly drawn between certain shales interbedded with or attached to the limestone series and others which overlie that series and are doubtless referable to the Cretaceous. This is also the opinion of Prof. Meek. (See his paper above referred to.) From a detailed study of all that bears on the subject I am led to believe that while the surface of the country generally is here composed of Cretaceous rocks, the river in some places cuts down to and exposes limestones and "bituminous shales" of the underlying series. The scale of the accompanying map is, however, too small to admit of the representation of such occasional exposures of the limestones, even where it is possible exactly to place these.

The Ramparts to The Narrows.

In latitude 66¾, about thirty miles below The Ramparts, is a perpendicular sandstone cliff, about one hundred and sixty feet high, which presents the same castellated appearance with that above noted. The beds are horizontal, and rest on horizontal strata of limestone. (2nd Exp., appendix p. xxxv,) Beyond this point, to "The Narrows," north of which the river divides and becomes estuarine in character, several outcrops of sandstone, marl-slate and shale were observed, all probably referable to the Cretaceous or Laramie.

Sandstones at The Narrows.

At The Narrows the sandstones are said to contain, "small, rounded, and also sharply angular grains of opaque, white, green and blue quartz with grains of lydian-stone and coal." (J. B. V., vol. i., p. 222.) These siliceous materials are, in all probability, fragments of the cherty beds of the limestone series. Such material forms a great part of many of the coarser Cretaceous beds of the Rocky Mountains where they have been geologically examined south of the latitude of the Peace River.

Peel River.

The Peel River, which flows into the Mackenzie not far below The Narrows, is said to show "the shale formation in its banks," (J. B. V., vol., i, p. 222), while Isbister mentions that alum-shales occur along it to the point at which it leaves the mountains. (Quart. Journ. Geol. Soc., vol. xi., p. 511. Journ. Royal Geog. Soc., vol. xv., p. 343.)

Porcupine River.

For the region west of the mountains, in this part of their length, the only information is included in the annexed note from Prof. Meek's paper:—"A few fossils in the collection under examination found by the Rev. Mr. W. W. Kirby along Porcupine River [a tributary of the Yukon] west of the Rocky Mountains, also indicate the continuation or reappearance of these rocks [Hamilton] on the western slope of the range, and their probable extension further westward into Russian America. The fossils here alluded to are *Favosites polymorpha*, apparently two or three species of undetermined turbinate corals, an aggregated *Cyathophyllum*, a *Palæocyclus*, *Atrypa aspera*, and *Cyrtina Hamiltonensis*" (p. 74).

Reindeer Hills.

The Reindeer Hills, on the east side of the estuarine part of the Mackenzie, are described as probably composed of limestone, a specimen of which was collected near their base at one point. The summit of one of the hills is, however, said to be of slate-clay and friable sandstone, and the height of the hills being inconsiderable, it is not improbable that they are largely formed of Cretaceous or Laramie rocks. (2nd Exp., appendix p. xxxviii.)

Probable occurrence of Tertiary.

It may be added in this connection that it is quite probable that still later Tertiary rocks may occur in the flat country of the lower part of the Mackenzie valley. So far, however, no palæontological evidence has been obtained of rocks newer than those which are elsewhere in the

western part of the continent classed as Laramie, and the information respecting these is so imperfect that it is quite impossible separately to define their area. They are, therefore, on the accompanying map, included with the Cretaceous under a single colour, a reference to some extent justified by the close palæontological approximation of the two series.

Country between Great Slave Lake and the mouth of the Coppermine River.

The following notes, embracing the information available, for the tract of country above defined, are extracts from or abstracts of those given by Richardson in Appendix I., to the narrative of Franklin's first journey (1819-22). The route pursued by the expedition is sufficiently indicated on the map by the chain of lakes running from Great Slave Lake to the upper part of the Coppermine River, to the north of which the river itself was followed.

Of the country north of the north arm of Great Slave Lake, Richardson writes:—"The granite formation continued for a considerable distance on our route towards Fort Enterprise, but it contained more and more foreign beds as we advanced to the northward. . . . At the mouth of Yellow Knife River, and in Lake Prosperous, mica slate prevailed. Between Rocky and Carp lakes, the granite contains many beds of mica-slate, and the country is tolerably well wooded" (p. 520). "At Carp Lake [lat. 63° 35′] the hills are of lower altitude, have fewer precipices, and more rounded summits; the valleys are less fertile, contain gravelly soil, and nourish fewer trees. This appears to be the commencement of the gneiss, or as it may be termed, in this latitude the *Barren Ground* formation, for it seems to exist throughout the great district to the eastward of the Coppermine River, termed the Barren Grounds by the Indians." (p. 520.)

Great Slave Lake to Fort Enterprise.

"The country about Fort Enterprise consists of short and very obtuse conical, or sometimes round-backed hills, of moderate elevations, never disposed in mountain ranges, but entirely unconnected and separated from each other by inclined valleys of moderate extent. Their summits are almost universally formed of naked smooth rock, and generally of a species of durable red granite that has been more than once mentioned as composed of well crystallized reddish felspar and grey quartz. Large, irregular, but somewhat cubical, fragments of this rock are scattered over the surface of the hills, or rest upon their very summits, by two or three angular points, as if left exposed there by the decay of the less durable material that enclosed them. . . . The acclivities of the hills, generally speaking, consist of gneiss wrapped in a mantle form, round the granite," (p. 520.)

Rocks at Fort Enterprise.

Following this general description (pp. 522-523), are local details respecting the vicinity of Fort Enterprise; granite, micaceous and hornblendic gneiss, greenstone, mica-slate and clay-slate, being mentioned.

Rocks at Point Lake.

Near the middle of Point Lake, lat., 65° 13′ or in the country in this immediate neighbourhood, the following rocks are noted by Richardson:—Greywacke passing into greywacke-slate, dark greenish or blackish-grey transition clay-slate, having a thick slaty structure, greywacke with small imbedded crystals of hornblende, transition greenstone, compact earthy greenstone, containing disseminated iron pyrites covered with layers of transition greenstone-slate. "On the north side of the lake, two miles from the encampment, there is a high bluff hill with a precipitous side, which seems to consist principally of a transition conglomerate. The basis is earthy clay-slate. The imbedded masses have an ellipsoidal form and smooth surface, and are from one to two feet in diameter, and appear to consist of the same material with the basis, but impregnated with much silica, and not showing evident slaty structure. When broken, they present an even fine-grained fracture." (p. 523.)

Age of the rocks.

Though, in consequence of the terminology in use at the time, the above descriptions of rocks are rather indefinite, so much so indeed that they might be supposed to represent rocks of the series now called Huronian, their connection with the rocks further down the Coppermine, subsequently described, renders it probable that they are referable to the continuation of the Cambrian of the Coppermine River. If so, they constitute the furthest south-eastern extension of the Coppermine River rocks yet recognized in this particular region.

Laurentian spurs.

With the probable exception of two places, where the older (Laurentian) rocks appear to come to the surface, the Cambrian rocks seem, from Richardson's description, to occupy the whole region traversed by the Coppermine River from Point Lake to the sea.

The following notes embody the principal recorded observations:—

Eleven and a half miles on a north-westward course from the last mentioned locality, greenish-gray clay-slate occurs. The rocks at the west end of Point Lake were then found, for some miles, to consist of granite and gneiss, probably Laurentian. The shores of Red Rock Lake are characterized by reddish and greenish-grey clay-slates, with hills apparently of trap. One of these "bore an exact resemblance in altitude and form to Salisbury Craigs, in the neighbourhood of Edinburgh." In latitude 66° 45′ 11″, gneiss and syenite hills were again observed on the north bank of the east-and-west reach of the river. These, I suppose from the description, to form an eastward projection from the large area of these older rocks between the Copper-

Red Rock Lake.

mine and Great Bear Lake. Beyond this point the rocks noted are as follows:—Dark red sandstone; dark purplish-red compact felspar rock, with a light reddish and greyish felspar and quartz rock, the low area characterized by these rocks is bounded to the northward, and eastward by a lofty ridge of trap rocks, which constitutes the famous Copper Mountains; reddish-grey granular foliated limestone; deep red sandstone, grey sandstone composed of grey quartz and felspar, pale red sandstone with quartz concretions, greyish-white siliceous sandstone with imbedded portions of the pale red kind; greenish felspathic trap, greenstone, flesh-red felspar and hornblende in concretions, with hornblende and amygdules of prehnite, hard wine-yellow limestone with thin layers of flint inclining to flinty-slate.

Cambrian rocks.

The above notes, taken in conjunction with Richardson's description of the Copper Mountains, appear to show, in so far as lithological criteria may be depended on, that representatives of both the Animikee and Keewenaw series of the Lake Superior region may occur here. The interest attaching to the Copper Mountains is so great as to justify the quotation of the paragraphs referring to them. They are as follows:—

Correspondence with Lake Superior Cambrian.

The Copper Mountains.

"The Copper Mountains appear to form a range running S. E. and N. W. The great mass of rock in the mountains seems to consist of felspar in various conditions; sometimes in the form of felspar rock or clay-stone, sometimes coloured by hornblende, and approaching to greenstone, but more generally in the form of dark reddish-brown amygdaloid. The amygdaloidal masses contained in the amygdaloid, are either entirely pistacite, or pistacite enclosing calc-spar. Scales of native copper are very generally disseminated through the rock, through a species of trap tuff, which nearly resembles it, and also through a reddish sandstone on which it appears to rest. When the felspar assumed the appearance of a slaty clay-stone, which it did towards the base of the mountains on the banks of the river, we observed no copper in it. The rough and in general rounded and more elevated parts of the mountain, are composed of amygdaloid; but between the eminences there occur many narrow and deep valleys, which are bounded by perpendicular mural precipices of greenstone. It is in these valleys, amongst the loose soil, that the Indians search for copper. Amongst the specimens we picked up in these valleys, were plates of native copper; masses of pistacite containing native copper; of trap rock with associated native copper, green malachite, copper glance or variegated copper ore, and iron-shot copper green; and of greenish-grey prehnite in trap, (the trap is felspar, deeply coloured with hornblende), with disseminated native copper: the copper in some specimens was crystallized in rhomboidal dodecahedrons. We also found some large tabular fragments, evidently portions of a vein consisting

Disseminated copper.

Mode of occurrence of copper.

of prehnite, associated with calcareous spar, and native copper. The Indians dig wherever they observe the prehnite lying on the soil, experience having taught them that the largest pieces of copper are found associated with it. We did not observe the vein in its original repository, nor does it appear that the Indians have found it, but judging from the specimens just mentioned, it most probably traverses felspathose trap. We also picked up some fragments of a greenish-grey coloured rock, apparently sandstone, with disseminated variegated copper ore and copper glance; likewise rhomboidal fragments of white calcareous spar, and some rock crystals. The Indians report that they have found copper in every part of this range, which they have examined for thirty or forty miles to the N. W., and that the Esquimaux come hither to search for that metal. We afterwards found some ice chisels in possession of the latter people, twelve or fourteen inches long, and half an inch in diameter, formed of pure copper."

Country north of the Copper Mountains.

"To the northward of the Copper Mountains, at the distance of ten miles, in a direct line, a similar range of trap hills occurs, having, however, less altitude. The intermediate country is uneven, but not hilly, and consists of a deep sandy soil, which, when cut through by the rivulets, discloses extensive beds of light-brownish red sandstone, which appears to belong to the new red sandstone formation*. The same rock, having a thin, slaty structure, and dipping to the northward, forms perpendicular walls to the river, whose bed lies a hundred and fifty feet below the level of the plain. . . . Beyond the last-mentioned trap range, which is about twenty miles from the sea, the country becomes still more level, the same kind of sandstone continuing as a subsoil. . . . A few ranges of trap hills intersect this plain also, but they have much less elevation than those we passed higher up the stream. The river, in its section of the plain, as far as Bloody Fall, presents alternately cliffs of reddish sandstone, and red-coloured slaty indurated clay or marl, and shelving white clay banks. At Bloody Fall, the stream cuts through a thick bed of dark purplish-red felspar rock,† similar to that observed at the Rocky Defile [about fifty miles further up the river to the southward] and associated, as at that place, with a rock composed principally of light red felspar and quartz, but which is probably a species of red secondary granite." (1st. Exp., pp. 528-530).

Bloody Fall.

* The undeveloped condition of the science of geology at the date at which Richardson wrote, led him to refer various rocks, on lithological grounds alone, to the New and Old Red Sandstone formations. He describes the rocks of the Coppermine series, here collectively referred to the Lower Cambrian, under the heads of Transition rocks, Old Red Sandstone, and New Red Sandstone. (1st Exp., p. 536).

† In the appendix to Franklin's Second Expedition (p. xlix). Richardson says he found this rock, on closer examination, to be greenstone, weathering rusty-brown.

A rolled piece of chromic iron was picked up on the banks of the Coppermine River by Dr. Rae, when accompanying Sir J. Richardson, in his search expedition in 1848. (J. B. V., vol, i., p. 327.) Chromic iron.

For additional facts on the vicinity of the mouth of the Coppermine, see the notes on a subsequent page, under the heading Arctic Coast.

Route from Great Slave Lake north-eastward by Clinton-Golden and Aylmer Lakes and the Great Fish River to the Arctic Coast.

The rock specimens collected by Captain Back on this route, and reported on by Dr. Fitton (Arctic Land Expedition, p. 547 *et seq.*), are all referable to the Laurentian, being different varieties of granite and gneiss. Two of the specimens were obtained on the shores of the inlet into which the Great Fish River discharges. Dr. Fitton, however, from Back's notes and observations, finds reason to believe that an area of rocks of the Coppermine River series occurs about Lake Beechy. The direction of the ranges of rough hills in that vicinity is north-west by south-east, and the strike of the rocks composing them may, therefore, be supposed to be the same with that of the rocks of Bathurst Inlet, near the mouth of the Coppermine, with which they are possibly continuous. The "trap formation," mentioned by Back, as seen near the mouth of the river (p. 372), evidently refers merely to a step-like contour of the rocky surface. Laurentian with Cambrian outliers.

Samuel Hearne gives an account of the great tract of otherwise unexplored country which lies between Back's route, above mentioned, and the west shore of Hudson Bay north of Fort Churchill, but very little can be gathered from his narrative with regart to its geological features. He states, indeed, that:—"The land throughout the whole track of country is scarcely anything but one solid mass of rocks and stones, and in most parts very hilly, particularly to the westward, among the woods."* Hearne's narrative,

This description, with other incidental remarks in the narrative (such as the abundance of islands in some of the lakes, recalling a feature almost universal in the lakes of the Laurentian country), may, so far as it goes, be taken to indicate that the region is chiefly or entirely composed of Archæan rocks—the "Barren Ground formation" of Richardson. There is certainly nothing on record to warrant a belief in the existence of a great tract of limestone rocks (Silurian), such as is shown on Isbister's map in this district and in which he is followed by Prof. J. Marcou, in his Carte Géologique de la Terre, (1875.) Neither is there anything in Back's narrative or Fitton's appendix to No great Silurian area.

* A Journey from Prince-of-Wales Fort, in Hudson's Bay, to the Northern Ocean, Dublin, 1796. p. 327.

bear out Isbister's statement (made on that authority) that limestone exists along the lower part of the Great Fish River. This misconception has probably arisen from the mention of limestone debris on one of the islands in the inlet at the mouth of the river. Anderson's report, of his subsequent traverse by the Great Fish River when in search of Sir J. Franklin, affords no geological information, and the same may be said of Lieut. Schwatka's narrative of his expedition from Hudson Bay to King William Land (1879-80.) Additional confirmation of the belief that the region between the Great Fish River and Hudson Bay is largely or entirely composed of Archæan rocks, is afforded by what is known of the west coast of Hudson Bay, the facts in connection with which are noticed on a subsequent page.

Arctic Coast, west of the Mackenzie River.

Northern extremity of Rocky Mountains.

Our knowledge of this region is very imperfect. On Petitot's map, the mountains immediately west of the mouth of Peel River, are marked as schist, while those to the south are said to be of limestone. The rocks thus classed as schist are probably referable to the same series with those of the Richardson and Buckland chains, referred to below.

Ranges parallel to the coast.

The Arctic coast, west of the Mackenzie, to longitude 148°, was explored by Franklin. The shore is described as low, but a short distance inland, there is a range of mountains running nearly parallel to it, comprising, from east to west, the Richardson, Buckland, British and Romanzoff chains. The low land, at least as far as the west end of the Richardson chain, is probably underlain by Cretaceous or Laramie rocks, continuous with those of the Mackenzie basin, as beds of lignite were observed at Garry Island, off the mouth of the Mackenzie, and near the Babbage River, opposite the west end of the Richardson chain. There is, however, nothing to indicate that these rocks terminate to the west at this place. (2nd Exp., appendix, p. xxiii.)

Cretaceous or Tertiary.

Probably Cambrian rocks.

Franklin collected a number of specimens from Mount Fitton, in the Richardson chain and Mount Conybeare, in the Buckland chain. These are described in some detail by Richardson as greywacke-slates, varying in colour and texture. The mountain range is believed by him to consist of "transition rocks" (2nd Exp. appendix, pp. xxvi-xxvii.) It is coloured as Cambrian on the present map, though with considerable uncertainty. The rocks referred to do not seem to resemble those of the Coppermine River series.

Exploration of Dease and Simpson.

From Franklin's furthest point, the coast was subsequently (1837) explored by Messrs. Dease and Simpson. It was found by them to be

uniformly low, with cliffs of frozen clay and sand, affording some reason for the belief that soft rocks, such as those of the Cretaceous or Laramie, run continuously along it. There appears to be, on this coast, a very remarkable absence of boulders or travelled blocks, as Simpson particularly notes a single angular mass of dark-coloured granite as the first and only rock seen by him. (Narrative of the Discoveries on the North Coast of America, etc., p. 149.)

Arctic Coast and Adjacent Lands East of the Mackenzie to Hudson Bay.

Continental Shore from Mackenzie River to Boothian Peninsula.

From Sir J. Richardson's description of the rocks along this coast, for about 270 miles east of the Mackenzie, or to the promontary of Cape Parry, they are referable, with little doubt, to the Cretaceous, or to that formation in conjunction with the superposed Laramie series. **Cretaceous and Laramie rocks.**

In the bay west of Cape Bathurst, cliffs of sand and slaty clay are noted. The extremity of Cape Bathurst is composed of cliffs of slaty clay, which, when dry, has a light bluish-grey colour. East of the Cape are beds of "alum-shale" said to resemble that of Great Bear Lake, previously referred to. At Point Trail, in this vicinity, cliffs or horizontally bedded "bituminous alum-shale" of a brown colour and interspersed with crystals of selenite and ironstone concretions, had been on fire. "The burnt clays, variously coloured, yellow, white, and deep red, give it much the appearance of the rubbish of a brick-field," (2nd Exp., appendix, pp. xli-xliii.) **Burnt shales.**

The circumstances here met with, apparently, exactly reproduce those presented by similar shales of the Fort St. John group (Cretaceous) on the Smoky River, a tributary of the Peace. (Report of Progress, Geol. Survey of Canada, 1879-80, p. 57 B.)

Slate-clay is again noted in cliffs at several points further east, to the bottom of Franklin Bay, and at one place, the shaly strata were actually observed to be in a state of combustion. (2nd Exp., appendix, p. xliii.)

In his subsequent Journal of a Boat Voyage (vol. i., p. 270), Richardson remarks of Cape Bathurst:—"I believe that this promontary, from its northern part to the bottom of Franklin Bay, is the termination of the sandy and loamy deposit and bituminous shale, which, throughout the whole length of the Mackenzie rests on the sandstone and limestone beds so frequently noted in the preceding pages, and fragments of which may be traced among the alluvial islands in the estuary of the Mackenzie, and in Liverpool Bay." (*Cf.* Bell, **Richardson's remarks.**

on Cretaceous rocks overlying Devonian limestones on Athabasca, Report of Progress, Geol. Survey of Canada, 1882-84, p. 14 cc.) It should be stated, in connexion with this district, that Petitot remarks, in a general way, that the country between the Anderson River (north of Great Bear Lake), and the Arctic coast, is granitic, with sandy and calcareous masses here and there overlying it (Bul. Soc. Géog., Paris, vol. x., p. 175). He also marks granite on his map, as occurring in two places near the coast between the mouth of the Mackenzie and Franklin Bay. It is thus possible that the area of Cretaceous rocks, in this vicinity, may not be so extensive or continuous as it is represented on the accompanying map, The continuous outcrop of limestone drawn between the Laurentian and Cretaceous rocks from the Mackenzie to Parry Peninsula, is scarcely more than hypothetical, as indeed the regularity of the outline given to it, will at once suggest to any geologist. Hamilton group fossils have, however, been described by Meek from collections made by McFarlane, at localities on the Anderson River, situated about a hundred and fifty miles in a north-eastward direction from The Ramparts of the Mackenzie (*Op. cit.*, p. 75). It must further be noted that notwithstanding the recognised value of Petitot's geographical work, the geological indications given by him—as judged by comparison with those of Richardson, where both refer to a single locality—must be accepted with great reserve.

Uncertainty of outlines of formations.

Limestones of Cape Parry.

Cape Parry, on the Arctic coast, and the promontary, or peninsula, of which it is the apex, appears to be composed entirely of limestone, yellowish-grey and brownish dolomite being most abundant. Where noted, the dip of these rocks is at low angles northward. The strata are compared by Richardson to those of The Rock by the River's Side on the Mackenzie, and to the limestones of Winnipeg Lake, and are doubtless either Devonian or Silurian in age. (2nd Exp., appendix, p. xliv.)

Extensive Cambrian area on the coast.

East of Cape Parry, for over seventy miles (Cape Lyon to Point Tinney), "the rocks forming the coast line are slate-clay, limestone, greenstone, sandstone and calcareous pudding-stone," and are recognized by Richardson as belonging to a formation differing from that met with further west. (2nd Exp., appendix, p. xlv.) Naked ridges of trap rocks are mentioned in some places, and splintery reddish limestone, slate-clay and limestone interstratified, compact bluish-black limestone and other rocks are described, the dips observed being generally to the north-eastward. Though the notes are rather imperfect for this part of the coast, it is believed to be occupied by an extension of the Cambrian rocks of the Coppermine, possibly with outliers of the Silurian or Devonian limestone in some places.

In his Journal of a Boat Voyage (vol. i., p. 283) Richardson makes the following additional important remarks respecting this portion of the seaboard:—"The quartz-rock beds acquire occasionally a pistachio-green colour, as if from the presence of epidote. A similar stone occurs at Pigeon River on the north shore of Lake Superior; and the limestones and sandstones of the latter district, with their associated trap rocks, as at Thunder Mountain [now classed as Animikie] correspond in most respects with those between Cape Parry and the Coppermine River." It may be observed, that in the narrative from which the above is quoted, Richardson does not distinguish so clearly between the probably Cambrian rocks and the horizontal limestone series, as in his appendix to Franklin's Second Expedition, while many of the geological notes given are evidently extracts from that appendix.

Beyond the district above described, from Point Clifton to Cape Hearne, in Coronation Gulf, "The whole coast consists of a formation of limestone precisely similar to that which occurs at Lake Winnipeg and Parry's Peninsula." (2nd Exp., appendix p. xlvii.) The strata are said to be nearly horizontal. **Silurian or Devonian limestones.**

On Rae River, which flows into Coronation Gulf from the west near the mouth of the Coppermine, limestone, bluish-grey quartz-rock and high cliffs of "basalt" are described from specimens and notes obtained by Dr. Rae, who ascended the river for about twenty miles in 1849. Among the limestone and quartz-rock, Dr. Rae discovered layers of "asparagus-stone or apatite, thin beds of soap-stone, and some nephrite or jade." In this connection Richardson further adds:—"From the similarity of the various rocks associated in this quarter, to those occurring at Pigeon River, and other parts of the north shore of Lake Superior, I am inclined to consider that the two deposits belong the same geological era, both being more ancient than the Silurian series." (J. B. V., vol. i., p. 312.) **Rae River.** **Apatite and jade.**

Near Rae River and Richardson River, immediately to the north-west of the mouth of the Coppermine, and also on the western side of the Coppermine River, Richardson describes a series of lines of "basaltic" cliffs. "All these precipices face towards the south, south-east, or east-south-east, and radiate between west and south-south-west from a point in Coronation Gulf, at which they would meet if prolonged. (J. B. V., vol. i., p. 316.) **"Basaltic Cliffs."**

A notice of the rocks near the mouth of the Coppermine and of the Copper Mountains has already been quoted from the narrative of Franklin's first journey. Nothing material is added to this by the observations in his second journey, but notes are there given of the rocks of the Barren Grounds between the mouth of the Coppermine and Dease Bay on Great Bear Lake. Rocks of the Coppermine River **Rocks between Coppermine and Great Bear Lake.**

series are described as extending westward to the height of land and consist chiefly of purplish, grey-spotted sandstone and conglomerate. (Appendix p. l.) So far as noted, the western slope appears to be composed of "granite" and "porphyry."

Coast east of Coppermine.

Eastward from the mouth of the Coppermine, the rocks of the coast and small islands lying off it, are described in the narrative of Franklin's first journey as similar to those of the Coppermine River, as far as Cape Barrow. It is unnecessary to enumerate them in detail. From what is said, the strike of the beds is probably nearly east-and-west on this part of the shore. Cape Barrow is undoubtedly Laurentian, being formed of red and grey granite, which rises in rough mountains, 1500 feet in height, and is associated with gneiss. The gneissic rocks are said to form a ridge, which runs southward at some distance from the west shore of Bathurst Inlet, but parallel to it, and is cut by Hood's River about fifteen miles above its mouth. The tract between the shore and this ridge is again evidently occupied by the Cambrian rocks, which are exposed in the lower part of Hood's River, and consist of trap and clay-slate.

Galena.

At Galena Point, fourteen miles south of Cape Barrow, on Bathurst Inlet, a narrow vein of pure galena was observed traversing gneissic rocks. (1st Exp., p. 531.)

Bathurst Inlet. Cambrian and Laurentian.

The shores of Bathurst Inlet generally are described as consisting partly of the rocks here assigned to the Cambrian, partly of granite and gneiss, the limits of the two series being noted with considerable precision. The islands in the inlet consist entirely of the Cambrian rocks, and these also compose both sides of Melville Sound, * though the gneiss formation again appears to the eastward, at the head of the sound.

From Bathurst Inlet, the route travelled by Richardson on his return journey diverged from Hood's River about fifty miles from its mouth, and ran south-westward to Point Lake and Fort Enterprise. After reaching the gneissic ridge above mentioned as crossing Hood's River, the rocks observed were entirely gneissic or granitic. (1st Exp., p. 534.)

Bathurst Inlet to mouth of Great Fish River.

In 1838-39, Messrs. Dease and Simpson explored the coast eastward from Franklin and Richardson's farthest point on Melville Sound, to beyond the mouth of Great Fish River, connecting there with the surveys of Ross. The geological notes given by Simpson, are, unfortunately, very meagre. His description of the coast, however, with the statement that the prevailing rock at Cape Alexander is a conglom-

* The eastern arm of Bathurst Inlet, not the large sheet of water known by the same name in the northern archipelago.

erate, while the sides of ravines are of red sandstone, (Narrative of the Discoveries on the North Coast of America, etc. p. 297), and the name Trap Point, applied to a place a few miles further east, leads to the belief that the Kent Peninsula, (south side of Dease Strait), forming the northern part of the continent in this region, is occupied by a continuation of the rocks of the Coppermine River series. Further east, the coast loses its bold character, and becomes low and stony, with a very irregular outline, and a fringe composed of innumerable little rocks, having a "striped and variegated appearance," (p. 364) and probably gneiss. Further on, granite is mentioned as forming the coast-line, which it appears probable may, with little doubt, be referred mainly or entirely to the Archæan. The western edge of the limestone formation occurs on this coast, at Cape Selkirk, east of the inlet into which the Great Fish River flows. East of Cape Selkirk, the country is described as a "flat, barren, limestone tract." (p. 376).

Islands Adjacent to the Coast.

Montreal Island, in the inlet at the mouth of Great Fish River, is invested with a melancholy interest in connection with the fate of members of Franklin's last expedition. It consists evidently of Laurentian rocks, the following being the description given of it by Prof. Haughton, in his Appendix to M'Clintock's Narrative of the Discovery of the Fate of Sir John Franklin.—"The granitoid rocks, which everywhere in the Arctic Archipelago, underlie the Silurian limestones, appear at Montreal Island as a gneiss, composed of bands of felspar (pink) and quartz (one-quarter inch thick), separated by thin plates, composed altogether of black mica; the whole rock exhibiting the phenomena of foliation in a marked degree." On page 209 of the same volume, M'Clintock notes that the stratification runs north-and-south, very regularly, and is nearly vertical. Montreal Island.

What is known of the geology of Wollaston, Victoria and King-William lands, may here appropriately be added, in connection with the description above given of the adjacent part of the continental shore.

Red sandstone is mentioned by Simpson as occurring at one place on the south shore of Victoria Land, north of Dease Strait, (Narrative of the Discoveries on the North Coast of America, etc.), but it remains uncertain from this notice whether it should be referred to the base of the Silurian or to the Coppermine River series. This point is, however, probably exceptional in its character, as Dr. Rae, who explored the entire south coast of Wollaston Land, with the south part of the east coast of Victoria Land, notes limestone rocks, or a low shore composed of limestone debris, almost everywhere, rendering it probable that the Victoria and Wollaston Lands.

strait separating these northern lands from the continent, also constitutes, for a great part of its length, the dividing line between the newer and older rock series. (*Cf.* Journ. Royal Geog. Soc., vol. xxii, 1852, pp. 73, 82).

Information furnished by Dr. Rae.

In letters received from Dr. Rae since the above was written, he confirms the indications derived from his paper in the Geographical Society's journal, as to the universality of the limestome formations along the south shore of Victoria and Wollaston lands, and states that the beds are nearly horizontal, and contain few or no fossils. The islands along the coast are, however, said to differ in character, being composed of gneiss or granitoid rocks. Some of these observed by him, are, probably, from his discription, amygdaloids. He adds that in the channel between Victoria Land and the main shore, opposite Cape Alexander, in lat. 69° N., long. 106° W. (approximatively), there are some rocky islets, composed of a remarkable conglomerate.

King-William Land.

The northern part of King-William Land, with Matty Island to the east of it, are described by Sir John Ross as of limestone. (Narrative of a Second Voyage in search of a North-west Passage, etc.) Simpson states the eastern part of the south shore to be also of limestone (*Op. cit.*, p. 379.) and Haughton dealing principally with the results of M'Clintock's voyage, writes as follows:—"The east side of King-William Island, though composed of Silurian limestone like the rest of the island, is strewed with blocks of black and red micaceous gneiss, like that of Montreal Island, and black metamorphic clay-slate, in which the crystals of mica are just commencing to be developed. It is probable that the granitoid rocks appear at the surface, somewhere to the eastward of this locality." (Appendix to M'Clintock's voyage).

Erratics.

Boothian and Melville Peninsulas and Vicinity.

Boothian Peninsula.

Numerous excellent, though brief notes on the geology of the eastern and south-western coasts of the Boothian Peninsula, occur in Sir John Ross' remarkable narrative above referred to. From these we learn that the eastern shore is composed of limestone to Port Logan (lat. 71° 21′) where a high range of hills,—which is seen at a distance, estimated at thirty miles inland at Creswell Bay (further north) and runs north-and-south,—impinges on the shore, and was found to consist of granitoid and gneissic rocks. Thence southward, from notes given in the body of the narrative, a narrow border of limestone may skirt the shore to about lat. 70° 35′, though the geological appendix does not make any mention of this. Further south, the granitoid and gneissic rocks exclusively form the coast line and adjacent islands to Lord Mayor's Bay, where Ross' observations connect with those of Dr. Rae, subsequently detailed. In Agnew River, on this coast, copper

ore was found by Ross, and massive beds of trap are mentioned in the appendix as occurring in the Saumerez River, though this is included in the area of country generally characterized by granite. The narrow neck of the Boothian Peninsula, which was crossed by Ross on several lines, is, from his description, composed of granitic rocks, with some outliers of limestone. One of these, definitely mentioned in the narrative but not in the geological appendix, is shown on the present map. On the coast of the mainland west of the isthmus, the limestone formation is found resting on the granites at Lake Wittersted. North-westward from the isthmus, the south-west coast of Boothia, presents a range of granitoid hills, running northward, but becomes fringed by a low border of limestone near Cape Isabella, and this increases in width to the north, till an extensive flat limestone region is found in the vicinity of the magnetic pole. Limestone outliers on Archæan.

The following description of the rocks of the vicinity of Bellot Strait, at the northern extremity of the Boothian Peninsula, is from Prof. Haughton's appendix to M'Clintock's voyage:— Bellot Strait.

"Bellot's Straits, lat. 72° N., separate North Somerset from Boothia Felix. The 'Fox' expedition wintered here in 1858, and had abundant means of ascertaining the geological structure of the neighbourhood. The junction of the granitoid and Silurian rocks occurs in these straits, the low ground to the east being horizontal beds of Silurian limestone, while on the west the granite hills of West Somerset rise to a height of 1600 feet above the narrow straits. The granite is here of three varieties:— Prof. Haughton's description.

"*α*. Blackish-grey fine grained, gneissose granite, composed of quartz, white felspar, and large quantities of fine grains and flakes of hornblende, passing into black mica. The gneissose beds of this granite dip 13° S.E.

"*β*. A red granite, graphic texture, composed of quartz and red felspar, coarse-grained.

"*γ*. Syenite, composed of honey-yellow felspar and hornblende, in very large crystals, the felspar passing into red and pink, and the whole rock mass penetrated by veins of the same material, but fine-grained. This variety of igneous rock was met with principally at Pemmican Rock, western inlet of Bellot's Straits. Large quantities of hornblende are also met with at Leveque Harbour, Bellot's Straits, composed of facetted crystals agglutinated together in large masses, forming a crystalline, hornblendic gneiss."

It is to be noted that Prof. Haughton's geological map does not, in the vicinity of Bellot Strait, entirely agree with the indications given in M'Clintock's narrative, on page 311 of which it is stated (in travelling northward on the west coast of Boothia), "we passed from lime- Continuous Archæan axis of the Peninsula.

stone to granite in lat. 71° 10′ N. Here the land attains a considerable elevation. In the hollows of the dark, granite rocks we found abundance of water," etc. On the detailed map of the strait, accompanying M'Clintock's narrative, its south shore is also marked as consisting of "irregular granite hills" (see also pp. 182, 189 and 230 for additional particulars on the outline of the granitoid rocks). The error above referred to is also pointed out by Prof. Marcou in his Explication d'une Second Edition de la Carte Géologique de la Terre, p. 130. The above observations, taken in connection with those of Ross, and including not only the actual notes on rocks, but also the trend of the mountains and other circumstances detailed, leave it scarcely doubtful that the granitic and gneissic rocks of southern Boothia connect with those of Bellot Strait, and form the axis of this remarkable projection of the continent, in the manner shown on the map accompanying these notes.

Gulf of Boothia.

From observations made by Dr. Rae, while engaged in his well known and remarkable exploration of the southern shores of the Gulf of Boothia, and detailed in his Narrative of an Expedition to the Shores of the Arctic Sea, we learn that Rae Isthmus and both shores of the Gulf of Boothia, northward nearly to latitude 70°, (with the exception of Simpson Peninsula, and possibly of one other locality), are composed of Archæan rocks. Granite is mentioned as occurring *in situ* in several places, and among specimens brought back are gneiss, mica-slate, granite, quartz-rock and hornblende-slate. It is possible that rocks both of the series now recognized as Laurentian, and that classed as Huronian, exist in this region. A specimen of lead ore was found on a hill in lat. 69° 13′ 14″ on the west side of the gulf, (*Op. cit.*, p. 115).

Simpson Peninsula limestone.

The whole of the Simpson Peninsula, above referred to, is probably composed of Devonian or Silurian limestone. At Keith Bay, on its south side, Rae remarks,—"Since passing Colville Bay the coast has become much lower and more level, giving every indication of a limestone country," (p. 107), and in crossing the narrow part of the peninsula, he observed limestone in place. (p. 108). In returning round the outer end of the same peninsula, he again notes its low, flat character, (p. 131), and on one of the maps accompanying the Arctic Blue Book of 1885, it is marked as "flat limestone country."

The second exceptional point on the shores of the gulf, is on the east side, in latitude 68° 27′, where precipitous cliffs of trap are mentioned by Rae, (p. 160). This rock may, however, be one of those of the Huronian series, or possibly even a dyke or intrusive mass cutting the Laurentian.

The region explored by Parry in his Second Voyage in Search of a North-west Passage, (1821-23), included the northern extremity of Southampton Island, with the entire west coast of Melville Peninsula and Hecla-and-Fury Strait at its northern extremity. The geological specimens brought back were examined by Prof Jameson, and the detailed maps of the expedition include indications of the character of the rock, at so many places, as to afford the means of tracing the geological outlines with very considerable accuracy. Granitic and gneissic rocks occupy the whole southern part of the east shore of Melville Peninsula, and are continued northward behind a low tract of limestone country, forming a range of mountains in the centre of the peninsula, to Hecla-and-Fury Strait. They also form the south shore of this strait, and most of the islands in it, and apparently the whole eastern shore of the adjacent south part of Cockburn "Island," (since shown by Dr. Boaz to form a part of Baffin Land). The western part of the same shore is marked as consisting of sandstone, probably of the kind designated "Old Red Sandstone, or red greywacke," by Jameson. It may be assumed to represent the red sandstones, elsewhere mentioned as so commonly found in the Arctic islands, at the base of the Silurian.

Melville Peninsula.

The rocks referred above, in a general way, to the Archæan, probably include areas of Huronian. Jameson mentions as among the prominent varieties of rocks derived from this region, "Granite, gneiss, mica-slate, clay-slate, chlorite-slate, primitive-trap, serpentine, limestone and porphyry." In association with these the following minerals occur:—"Zircon and beryl, also precious garnet, actinolite, tremolite, diallage, coccolite, rock crystal, calc-spar, rhomb-spar, asbestos, graphite or black lead, specular iron ore, magnetic iron ore, chromic ore or chromate of iron, titanic iron, common and magnetic iron pyrites." Some of the "transition rocks," noticed by Jameson, should probably also be classed with the Archæan, and in addition to several of the minerals above mentioned, in these were found tourmaline (schorl) and molybdenite. (Narrative of Discovery and Adventure in the Polar Seas and Regions, by Professors Leslie, Jameson, and Hugh Murray, 1830.)

Rocks and minerals described by Jameson.

The northern extremity of Southampton Island, as shown by Parry in the volume above referred to, consists of granitic and gneissic rocks, which may be regarded as Laurentian, though limestones form the country toward the west shore, at the head of Duke-of-York Bay. Captain Back, who, during the winter of 1836-37, was beset in the ice, and drifted slowly south-eastward along the whole north-east shore of Southampton Island, describes it as generally high, rough and mountainous. At two places at which he landed, he notes the rocks as

North-east coast of Southampton Island.

granite, adding that the rocks of one locality were "striated granite." (Narrative of an Expedition in H. M. S. 'Terror,' pp. 131, 189.) It may thus be assumed that this coast is in general Archæan, though the mention of lower, rounded hills at two places, said to indicate a "different formation," leads to the belief that outlying areas of limestone occur on it.

West Coast.

Sea horse Point, forming the east cape of Southampton Island, is described by Lyon as high, in his Narrative of an Unsuccessful Attempt to reach Repulse Bay (1824), p. 51, while the coast to the south and west, with the entire west coast of the island, so far as seen by him and by Middleton (1741), is low and shingly with flat limestone rocks. Cape Fullerton, on the continental shore to the west, is said, by Lyon, to be composed of "rugged red and grey granite rocks, with the strata running in a north-west direction." (*Op. cit.*, p. 88.)

West Coast of Hudson Bay.

On the portion of the west coast of Hudson Bay, to the north of Fort Churchill, besides the above allusion, we have a number of brief notes by Dr. Rae, who traversed it on his outward and return journeys to Repulse Bay, and describes it in his work already referred to. Of Dr. Rae's notes, the following summary may be given:—At forty miles north of Churchill, the land becomes much lower than at that place, and the coast so flat that it was necessary, with boats, to keep six to eight miles off it (*Op. cit.* p. 20.) The coast preserves the same low character northward as far as Cape Esquimaux, in about latitude 61°, beyond which, in Nevill's Bay, the "shore becomes steep and rugged, the whole coast being lined with bare primitive rocks" (p. 24.) Between this point and Repulse Bay, in the course of the two journeys above referred to, granite and gneiss were observed in a number of places, and no mention is made of other rocks *in situ*, though among specimens collected, and reported on by Prof. Tennant in the appendix, hornblende- and mica-slates and chloritic and talcose slates are noted. On an island near the south shore of Ranken Inlet, Rae "picked up some specimens of copper ore, but the ore did not appear to be abundant."

Huronian rocks

Dr. Rae's observations would thus appear to place the probable northern limit of the limestone formation, which borders the west coast of Hudson Bay to the southward, near Cape Esquimaux. It must be added, however, that from specimens given to and reported on by Dr. Bell, in the Annual Report of the Geological Survey for 1885 (p. 19 DD.), the coast north of Cape Esquimaux appears to be by no means entirely composed of Laurentian rocks, as he is inclined to refer the majority of these specimens, on lithological grounds, to the Huronian formation. Marble Island, lying off this coast, is further described by Dr. Bell, from actual inspection, as consisting of light-coloured, fine-grained quartzite, associated with glossy mica-schists.

Northern Continental Shore, East of Hudson Bay, with Baffin Land.

Dr. R. Bell, of the Canadian Geological Survey, has made several expeditions to Hudson Bay, the reports on which, together with his observations in Hudson Strait and the coast of Labrador, have afforded the greater part of the information employed in indicating the geological character of the part of the continental shore east of Hudson Bay, with the north shore of Hudson Strait. It is considered unnecessary to summarize the portions of the reports mentioned which bear on these coasts, as they have already been published by the Survey. The following may be consulted in this connection :—Report on Explorations of the East Coast of Hudson Bay, 1877-78 ; Report on Hudson Bay and some of the Lakes and Rivers lying to the West of it, 1879-80 ; Observations on the Geology, Mineralogy, &c., of the Labrador Coast, Hudson Strait and Bay, 1882-84 ; Observations on the Geology, Zoology, &c., of Hudson Strait and Bay, 1885 ; The Geology of Hudson Bay and Strait ; Report of the Hudson Bay Expedition of 1885 ; Marine Department, Ottawa. **Reports by Dr. Bell.**

In the Transactions of the Geological Society, vol. ii. (1814.) Rev. Mr. Steinhauer describes a number of specimens sent by the Moravian missionories from the Labrador coast, and gives localities for labradorite, and for the soapstone used by the Eskimo in making lamps, etc. **Steinhauer on Labrador.**

The rocks described as the Manitounuck formation (Lower Cambrian) by Dr. Bell, are largely developed in the vicinity of Richmond Gulf, on the east side of Hudson Bay, but are not known to extend northward to the southern limit of the accompanying map. From his observations on the northern part of the east coast, Dr. Bell considers it probable that rocks of the Laurentian system extend southward from Cape Wolstenholme to Mosquito Inlet (Report last cited, p. 61), while Nottingham and Digges islands, together with both shores of Hudson Strait, so far as examined, were found to consist of the same rocks. With the possible exception of part of the north shore of Nachvak Inlet, which may be Huronian (see Report 1882-84) the rocks of the Labrador coast, wherever observed, are also referred to the Laurentian, gneiss of varied texture being here, as elsewhere, the prevailing material. As confirmatory of the entirely Laurentian character of the northern part of the Labrador coast, the notes and geological map of Mr. O. M. Lieber may be referred to. (Appendix No. 42, U. S. Coast Survey, 1860.) Dr. Bell specially mentions the occurrence of mica and graphite on the north shore of Hudson Strait, as being of possible economic importance. **Hudson Strait and Northern Labrador.** **Mica and Graphite.**

Western end of Hudson Strait. Fox Land.

Little is known as to the north shore of the western extremity of Hudson Strait, and nothing directly of its geological features. It may be assumed to consist either of the prevailing Archæan rocks or of the overlying Silurian limestones, and on this assumption, the following description, by Coats, leaves little room to doubt that it must be assigned to the first mentioned series:—"Cape Charles, on the eastern side of the North Channel, is twelve leagues north-east from these islands. [Mill Islands of Baffin, situated north-west of Salisbury Island of the map.] These islands and the main to the eastward of the North Channel, are all high, bold, mountainous land, and are indented in bays and coves, and the hills are cut and interspersed with valleys, very foul and rocky, and deep water everywhere near them." (Coats' Geography of Hudson Bay. Hakluyt Society, vol. ii., 1852, p. 73). Coats also describes Salisbury Island as high and bold. The profile sketches of the same coast given by Parry in his "Third Voyage," (sheet 1), bear out Coats' description, and prove the resemblance in physical features of this coast to that of the north shore of she eastern part of the strait, which is known to be Laurentian. Nothing can be gathered as to the geology of Fox Land, from the narrative of Luke Fox, the original discoverer, (1631).

Baffin Land.

Little information is available, respecting the geology of the interior of Baffin Land. A few notes by Dr. Franz Boas, are quoted in full by Dr. Bell in the Annual Report of the Geological Survey for 1885. Dr. Boas describes the nucleus of the mountain masses as everywhere gneiss and granite, while Silurian limestones occur at Lake Kennedy (Nettilling of his map) and to the south of it. He also refers to the occurrence of the same rocks at the head of Frobisher Bay. (Petermanns Mitteilungen, Ergänzungsheft, Nr. 80, 1885.) Dr. Boas further informs me that from the description of the country between Cape Kater and Fox Channel, he believes the granitic rocks there to extend to the west coast of Baffin Land.

The Archæan range, which borders the east coast of Baffin Land, is evidently the continuation of that of the Labrador coast. Prof. Jameson, however, states (presumably as the result of his examination of specimens collected by Captain Parry), that on the west coast of Davis Strait and Baffin Bay, south of Lancaster Sound, primitive rocks preponderate. He enumerates gneiss, mica-slate and granite. (Narrative of Discovery and Adventures in the Polar Seas and Regions, etc.)

Collections by Parry and Ross

The specimens collected by Captain Ross, in 1818, on the west side of Baffin Bay, which are described in an appendix to his voyage (A Voyage of Discovery for the Purpose of Exploring Baffin's Bay, etc.) by Dr. McCulloch, having been apparently picked up without any discrimination, and consisting chiefly of loose pieces from two localities, give

little information. Those from lat. 70° 37′, were granite, gneiss and greywacke-schist. (vol. ii., p. 141.)

In a Supplement to the Appendix of Capt. Parry's Voyage for the Discovery of a North-west Passage in the years 1819–20 (Natural History) C. Koning describes the most characteristic rocks of the west coast of Baffin Bay as "gneiss and micaceous quartz-rock, with some ambiguous granitic compound, in which hornblende seems to enter as a subordinate ingredient (p. ccxlvii).

Remarks by Sutherland.

Dr. P. C. Sutherland, in the Quarterly Journal of the Geological Society (vol. ix., 1853, p. 299), describes the east coast of Baffin Land from Lancaster Sound to Cumberland Sound, as follows:—"On the opposite [south] shore of Lancaster Sound, at Cape Walter Bathurst, the crystalline rocks are again recognized, and from this point they occupy the whole coast southward to Cumberland Strait [Sound] and probably considerably beyond it. To this, however, I believe there is one exception, at Cape Durban, on the 67th parallel, where coal has been found by whalers; and also at Kingaite, two degrees to the south-west of Durban, where, from the appearance of the land as viewed from a distance, trap may be said to occur on both sides of the inlet. Graphite is found abundant and pure in several islands situated on the 65th parallel of latitude in Cumberland Strait, and on the west side of Davis Strait."

Rocks of Frobisher Bay.

A considerable collection of rocks and fossils, made by C. F. Hall, chiefly in Frobisher Bay and its vicinity, is described by Prof. B. K. Emerson, in Appendix III., to Hall's Narrative of a Second Arctic Expedition. The greater number of these specimens consist of ordinary Laurentian rocks, including granite, gneiss, magnetite-gneiss, hornblendic gneiss, mica-schist, etc. In association with these, in Frobisher and Field Bays, magnetite, apatite, bornite and pyrite were found, together with crystalline limestone holding coccolite. At the head of Frobisher Bay, from a hill named by Hall "Silliman's fossil mount,"* which appears to form part of a somewhat extensive development of nearly horizontal cream-coloured and sometimes magnesian limestone, a number of fossils were obtained. These, according to Prof. Emerson, represent both Upper Silurian and Utica shale forms. Several of the fossils are named and figured by him in the appendix. The limestone is evidently in place at this locality, but specimens of the same rock picked up by Hall on other parts of Frobisher Bay and at Field Bay, may probably have been erratics, as the Archæan rocks appear everywhere to preponderate in this region.

Copper and iron ores.

* The position of "Silliman's fossil mount" is shown on the map accompanying Hall's Life with the Esquimaux. London, 1864.

Notes by Endlich and Haughton.

Mr. F. M. Endlich, in a list of minerals obtained in the Howgate Polar expedition (1877-78) enumerates, among others, the following from Cumberland Sound:—Muscovite, crystals and large plates; chalcopyrite, pyrrhotite, apatite (Smithsonian Miscellaneous Collections, 1882, p. 171.)

In his appendix to M'Clintock's voyage, Prof. Haughton gives the following, respecting the south shore of Pond's Bay, or inlet at the northern extremety of Baffin Land. (Lat. 72° 40′). "In this locality, a quartziferous black mica-schist underlies the Silurian limestone, and is interstratified with gneiss and garnetiferous quartz-rock, all inclined 38° W.S.W. (true)." M'Clintock states the inclination or dip of the beds as 35° to the west, in the same volume. (p. 156).

The Arctic Archipelago.

Definition.

The following notes include the islands lying to the north of the American continent which have not already been noticed in connection with the shores of the mainland, with the exception of Baffin Land, (previously described), and Grinnell and Ellesmere lands which are subsequently referred to.

Haughton's memoirs.

In Appendix IV. to Captain M'Clintock's Narrative of the Discovery of the Fate of Sir J. Franklin, Professor S. Haughton gives a geological map of the Arctic Archipelago, and a remarkably clear and succinct account of its geological features, based principally on the specimens brought back by M'Clintock from the four Arctic expeditions in which he served, from 1848 to 1859. The extensive suite of specimens above referred to is now deposited in the museum of the Royal Dublin Society. In the same memoir and in his map, Prof. Haughton incorporated nearly all the information available on the region, and with our present knowledge, it is scarcely possible to improve on his sketch. The following pages are therefore largely a transcript of his appendix, the same order of arrangement being observed as that adopted by him. I have, however, added a few facts which appear to throw additional light on the geology of the Arctic islands. The greater part of his observations on the Greenland coast are also here omitted, together with the lists of fossils given by him, and most of the notes relating to the superficial deposits. The geological map accompaning Prof. Haughton's appendix, is based on that of an earlier paper published by him in the Transactions of the Royal Dublin Society in 1857. The arrangement adopted by Prof. Haughton is as follows:—

1. *The Granitic and Granitoid Rocks.*
2. *The Upper Silurian Rocks.*
3. *The Carboniferous Rocks.*
4. *The Lias Rocks.*
5. *The Superficial Deposits.*

Classification adopted.

1. *The Granitic and Granitoid Rocks.* "These rocks form a considerable part of North Greenland, on the east side of Baffin Bay, and constitute the rock of the country at the east side of the island of North Devon, which forms a portion of the coast-line of the west of Baffin Bay, and the north side of the entrance to Lancaster Sound."

Granitoid rocks

"Capes Osborne and Warrender, lat. 74° 30′ N., North Devon.—The granitoid rocks between these two capes are composed of graphic granite, consisting of quartz, (grey), and white felspar; this graphic granite passes into a laminated gneiss, consisting of layers of black mica, and white translucent felspar, sparingly mixed with quartz; with the gneiss are interstratified beds of garnetiferous mica-slate, consisting of quartz, pale greenish-white felspar, black and white mica in minute spangles, and crystals of garnet, rose-coloured, disseminated regularly through the mass. Quartziferous bands of epidotic hornstone occur with the foregoing beds; and the whole series is overlaid by red sandstones, of banded structure, which bear a striking resemblance to those that overlie the granitoid beds of Wolstenholme Sound."

Capes Osborne and Warrender

"North Somerset.—The granitoid rocks are found again on the west side of the island of North Somerset, where they form the eastern boundary of Peel Sound. Boulders of granite are found at a considerable distance, (100 miles), to the north-eastward of the rock *in situ*, as at Port Leopold, Cape Rennell, etc. The general characters of the granitic rocks in the north and west of North Somerset, are thus described by Capt. M'Clintock:—'Near Cape Rennell we passed a very remarkable rounded boulder of gneiss or granite; it was six yards in circumference, and stood near the beach, and some fifteen or twenty yards above it; one or two masses of rounded gneiss, although very much smaller, had arrested our attention at Port Leopold, as then we knew of no such formation nearer than Cape Warrender, 130 miles to the north-east; subsequently we found it to commence *in situ* at Cape Granite, nearly 100 miles to the south-west of Port Leopold. The granite of Cape Warrender differs considerably from that of North Somerset; the former being a graphic granite, composed of grey quartz and white felspar, the quartz predominating; while the latter, a North Somerset granite, is composed of grey quartz, red felspar, and green, chloritic mica, the latter in large flakes; both the granite and gneiss of North Somerset are remarkable for their soapy feel.'"

North Somerset.

Junction of granitic and limestone series.

"To the east of Cape Bunny, where the Silurian limestone ceases, and south of which the granite commences, is a remarkable valley called Transition Valley, from the junction of sandstone and limestone that takes place there. The sandstone is red, and of the same general character as that which rests upon the granitoid rocks at Cape Warrender and at Wolstenholme Sound. Owing to the mode of travelling, by sledge on the ice, round the coast, no information was obtained of the geology of the interior of the country, but it appears highly probable that the granite of North Somerset, as well as that of the other localities mentioned, is overlaid by a group of sandstones and conglomerates, on which the Upper Silurian limestones repose directly. A low sandy beach marks the termination of the valley northwards, and on this beach were found numerous pebbles, washed from the hills of the interior, composed of quartzose sandstone, carnelian and Silurian limestone."

It may be added in this connection that Sir R. Murchison, in his geological appendix to M'Clure's voyage (p. 402) writes:—"In North Somerset, to the south of Barrow Strait, red sandstone is associated with the older limestone." (See also remarks on page 9 R of these notes)

Cape Granite.

"Cape Granite is the northern boundary of the granite, which retains the same character as far as Howe Harbour. It is composed of quartz, red felspar, and dark green chlorite; and is accompanied with gneiss of the same composition. I have in my possession a specimen of this granite, found as a pebble at Graham-Moore Bay, Bathurst Island, S.W., a locality 135 knots distant from Cape Granite, to the N.W."

Prince-of-Wales Island.

Prof. Haughton's notes on Bellot Strait, Pond's Bay and Montreal Island, have been quoted on previous pages—in connection with the coast of the mainland. Of Prince-of-Wales Island, west of Peel Sound, he writes:—"The granitoid rocks extend across Peel Sound into Prince-of-Wales Island, in the form of a dark syenite, composed of quartz, greenish-white felspar passing into yellow, and hornblende. This rock is massive and eruptive at Cape M'Clure, lat. 72° 52′ N., and occasionally gneissose, as at lat. 72° 13′ N. Between these two points, at lat. 72° 37′ N., a limestone bluff occurs, containing the characteristic Silurian fossils, and is succeeded at 72° 40′ by a ferruginous limestone, bright red, and a few beds of fine red sandstone, like those observed by M'Clintock at Transition Valley, North Somerset. The entire western portion of Prince-of-Wales Land is composed of Silurian limestone, which in the extreme west, at Cape Acworth, becomes chalky in character and non-fossiliferous, resembling the peculiar Silurian limestone found on the west side of Boothia Felix."

The Silurian Rocks.—"The Silurian rocks of the Arctic Archipelago rest everywhere directly on the granitoid rocks, with a remarkable red sandstone, passing into a coarse grit, for their base. This sandstone is succeeded by a ferruginous limestone, containing rounded particles of quartz, which rapidly passes into a fine greyish-green earthy limestone, abounding in fossils, and occasionally into a chalky limestone, of a cream colour, for the most part devoid of fossils. The average dip of the Silurian limestone varies from 0° to 5° N.N.W., and it forms occasionally high cliffs, and occasionally low flat plains, terraced by the action of the ice as the ground rose from beneath the sea. The general appearance of the rocks is similar to the Dudley limestone, and would strike even an observer who was not a geologist. This resemblance to the Upper Silurian beds extends to the structure of the rocks on a large scale. Alternations of hard limestone and soft shale, so characteristic of the Upper Silurian beds of England and America, arranged in horizontal layers, give to the cliffs around Port Leopold [north-east part of North Somerset] the peculiar appearance which has been described by different Polar navigators as 'buttress-like,' 'castellated'; this appearance is produced by the unequal weathering of the cliff, which causes the hard limestone to stand out in bands. . . . The western side of King-William Island is an excellent example of the low terraced form which the rocks assumed at times." Silurian rocks.

Prof. Haughton gives lists of Silurian fossils brought home by Captain M'Clintock from the following places:—Garnier Bay (lat. 74° N.; long. 92° W.), Port Leopold (lat. 73° 50′ N., long. 90° 15′ W.), Griffith's Island (lat. 74° 35′ N.; long. 95° 30′ W.), Beechy Island (lat. 74° 40′ N.; long. 92° W.), Cornwallis Island, Assistance Bay (lat. 74° 40′ N.; long. 94° W.), Cape York, Lancaster Sound (lat. 73° 50′ N.; long. 87° W.), Possession Bay, south entrance to Lancaster Sound (lat. 73° 30′ N.; long. 77° 20′ W.), Dêpot Bay, Bellot Strait (lat. 72° N.; long. 94° W.), Cape Farrand, east side of Boothia (lat. 71° 38′ N.; long. 93° 35′ W.), west shore of Boothia (lat. 70° to 71° N.); Fury Point (lat. 72° 50′ N.; long. 92° W.), Prince-of-Wales Land (lat. 72° 38′ N.; long. 97° 15′ W.), west coast of King-William Island. Localities of Silurian fossils.

From the appendix to Parry's Third Voyage, we learn that in association with the limestones of the east side of Prince-Regent Inlet, are subsidiary beds of gypsum. Gypsum also occurs on the west side of the inlet in North Somerset, where it is said to occur in "beds several feet thick, extending for at least thirty miles through the country." (App. p. 147.) At the first mentioned locality, brown hæmatite was also found, apparently derived from the limestone. Occurrence of beds of gypsum.

The existence of such considerable deposits of gypsum is interesting, on account of the close association of limestones and gypsums in rocks classed by Meek as Devonian on the Mackenzie River, which there is some reason to believe occur also in the region here described, but have not yet been separated from the Silurian.

Carboniferous rocks.

The Carboniferous rocks are thus described by Prof. Haughton:—"The Upper Silurian limestones, already described, are succeeded by a most remarkable series of close-grained white sandstones, containing numerous beds of highly bituminous coal, and but few marine fossils. In fact, the only fossil shell found in those beds, so far as I know, in any part of the Arctic Archipelago, is a species of ribbed *Atrypa*, which, I believe, to be identical with the *Atrypa fallax* of the Carboniferous slate of Ireland. These sandstone beds are succeeded by a series of blue limestone beds, containing an abundance of the marine shells, commonly found in all parts of the world where the Carboniferous deposits are at all developed. The line of junction of these deposits with the Silurians on which they rest is N.E., to E.N.E. (true.) Like the former, they occur in low, flat beds, sometimes rising into cliffs, but never reaching the elevation attained by the Silurian rocks in Lancaster Sound.

Coal formation.

"Coal, sandstone, clay-ironstone and brown hæmatite, were found along a line stretching E.N.E. from Baring Island, through the south of Melville Island, Byam-Martin Island, and the whole of Bathurst Island. Carboniferous limestone, with characteristic fossils, was found along the north coast of Bathurst Island, and at Hillock Point, Melville Island."

Localities of fossils and rock-specimens

From a comparison of different coal exposures noted by M'Clintock, M'Clure, Austen, Belcher, and Parry, in the Parry Islands, Prof. Haughton has laid down the approximate outcrops of some of the coal beds. These he finds to agree remarkably well with the trend of the boundary of the formation drawn from totally different data. Lists of fossils and rocks from the following places, with notes, are given:—Hillock Point, Melville Island (lat. 76° N.; long. 111° 45′ W.) Bathurst Island, north coast, Cape Lady Franklin (?) (lat. 76° 40′ N.; long. 98° 45′ W. Princess-Royal Island, Prince-of-Wales Strait, Baring Island (lat. 72° 45′ N.; long. 117° 30′ W.) In connection with this place, it is noted that the Carboniferous sandstones underlie the limestones, and that "it is highly probable that the coal beds of Melville Island are very low down in the series, and do not correspond in geological position with the coal beds of Europe," (p. 385.)*

* Dr. Armstrong in his Narrative of the Discovery of the North-west Passage (p. 402), says of the same place, "In Princess-Royal Island, besides the characteristic Silurian limestones, there are black basalts and red jaspers, as well as red rocks, less altered by heat, but showing a passage into jasper."

Cape Hamilton, Baring Island (lat. 74° 15′ N.; long. 117° 30′ W.) Cape Dundas, Melville Island (lat. 74° 30′ N.; long. 113° 45′ W.) Cape Sir-James-Ross, Melville Island (lat. 74° 45′ N.; long. 114° 30′ W.) Cape Providence, Melville Island (lat. 74° 20′ N.; long. 120° 30′ W.) Winter Harbour, Melville Island (lat. 74° 35′ N.; long. 110° 45′ W.) Bridgeport Inlet, Melville Island (lat. 75° N.; long. 109° W.) Skene Bay, Melville Island (lat. 75° N.; long. 108 W.) Hooper Island, Lyddon Gulf, Melville Island (lat. 75° 5′ N.; long. 112° W.) Byam-Martin Island (lat. 75° 10′ N.; long. 104° 15′ W.) Graham-Moore Bay, Bathurst Island (lat. 75° 30′ N.; long. 102° W.) Bathurst Island, Bedford Bay (lat. 75° N.; long. 95° 50′ W.) [Vesicular scoriaceous trap rocks were found here by M'Clintock, though no such rocks are mentioned elsewhere in connection with the Carboniferous.] Cornwallis Island, McDougall Bay. Silurian and Carboniferous fossils were found together at the last mentioned place. The questions raised by these are discussed by Haughton on page 389.

Prof. Haughton also notes that "the sandstone of Byam-Martin Island is of two kinds — one red, finely stratified, passing into purple slate, and very like the red sandstone of Cape Bunny, North Somerset, and some varieties of the red sandstone and slate found between Wolstenholme Sound and Whale Sound, West Greenland, lat. 77° N. The other sandstone of Byam-Martin Island is fine, pale-greenish, or rather greyish-yellow, and not distinguishable in hand specimens from the sandstone of Cape Hamilton, Baring Island." Parry also describes Byam-Martin Island as essentially composed of sandstone, with some granitic and felspathic rocks, these last being probably erratics. Byam-Martin Island.

Respecting the coal seams which have been discovered in the Arctic Archipelago, Prof. Haughton further remarks:— "If the different points where coal was found be laid down on a map, we have, in order, proceeding from the south-west, Cape Hamilton, Baring Island; Cape Dundas, Melville Island, south; Bridgeport Inlet and Skene Bay, Melville Island; Schomberg Point, Graham Moore Bay, Bathurst Island; a line joining all these points is the outcrop of the coal-beds of the south of Melville Island, and runs E.N.E. At all the localities above mentioned, and indeed, in every place where coal was found, it was accompanied by the greyish-yellow and yellow sandstone, already described, and by nodules of clay-ironstone, passing into brown hæmatite, sometimes nodular and sometimes pisolitic in structure," (p. 388.) Coal outcrops.

Prof. O. Heer describes and figures fossil plants, from the Lower Carboniferous sandstones, which he subsequently referred to his "Ursa stage," from Melville and Bathurst islands in his Flora Fossilis Arctica, Fossil plants.

vol. i. (See also Quart. Journ. Geo. Soc., vol. xxviii, 1872 and remarks made on page 11 R of these notes).

Armstrong on Baring and Banks Lands.

In his Narrative of the Discovery of the North West Passage, Dr. Armstrong, surgeon and naturalist to the 'Investigator,' describes the limestone formation, (Silurian), of Nelson Head, the south point of Baring Land, (p.212), and gives geological notes on other places in Prince-of-Wales Strait, and on the coasts of Baring and Banks lands. Those referring to the northern part of the latter, though somewhat contradictory, appear to indicate,—in addition to the sandstones and shales with coaly streaks, of the formation subsequently referred to the "Ursa stage,"—the existence of exposures, (outliers?) of Carboniferous limestone at Cape Crozier and near Mercy Bay. Heer follows these indications on his map, and they are also adopted on that accompanying these notes.

Eastward continuation of Lower Carboniferous.

In a paper on Arctic Silurian Fossils in the Quarterly Journal of the Geological Society, (vol. ix., p. 315), J. W. Salter states that Dr. Sutherland and Captain Stewart found limestones on the east side of Wellington Channel, (south-west coast of North Devon), to lat. 76° 21′, and even further westward along the part of the coast which trends in that direction, to long. 97°. He also mentions specimens of fossils characterized by him as Upper Silurian, from Hamilton and Dundas islands, in Wellington Channel. Haughton, in his map of the Arctic Archipelago, shows the Silurian boundary further north than it appears in the map by DeRance in "Nature," and the observations above quoted would seem to carry it even further to the north-west than shown by Haughton, Prof. Haughton does not indicate the distribution of the "Lower Carboniferous sandstones with coal," or beds of the "Ursa stage" in North Devon, while DeRance, on his map shows them running across that island as a wide belt, but in his description writes:— "The Lower Carboniferous, close-grained, white sandstone, ("Ursa stage" of Heer), with beds of coal, strikes S.W. and N.E. from Baring or Banks Land, where it rests on the Silurian, through Melville Island to Bathurst Island, where it disappears under the Carboniferous limestone between Penny Strait and Queen's Channel."

Additional information required.

There is an unfortunate lack of precise information for the portion of North Devon which it might be anticipated these sandstones would occupy, but it appears probable that if they occur there, they characterize but a narrow belt of country, as Dr. Sutherland's notes, above referred to, carry the Silurian limestone north, on the shore of Wellington Channel, nearly to the points at which Carboniferous limestone was observed by Belcher's expedition. Whether the Lower Carboniferous sandstones entirely disappear, and if so, whether from an unconformable overlapping of the Carboniferous limestone on the

Silurian, or an actual dying out of the beds in this direction, remains uncertain. I have ventured to carry the Lower Carboniferous sandstones across North Devon, with a reduced width. It is interesting to observe that these rocks were not seen by Nares' expedition in Grinnell Land, in the far north, though the Carboniferous lime stone, as well as Devonian rocks, occur there.

Liassic Rocks. The extent and distribution of the rocks described by Prof. Haughton as Lias, is not known, their existence being determined merely by the occurrence of certain fossils at three rather widely separated localities in the northern part of the Arctic Archipelago, *viz:* at Point Wilkie, in Prince-Patrick Island, Rendezvous Hill, near the north-western extreme of Bathurst Island, and Exmouth Island and places in its vicinity near the north part of Grinnell Island.* These rocks may spread much more widely than is at present known, as a formation overlying the Carboniferous limestone of these northern islands. The fossils from the first mentioned locality are described as *Ammonites M'Clintocki*, *Monotis septentrionalis*, *Pleurotomaria* sp. *Nucula* sp., and the cast of a univalve, together with various fragments of reptilian bones. The molluscs are figured in the Journal of of the Royal Dublin Society, Vol. I., and one of them, *Harpoceras* (*Ammonites*) *M'Clintocki*, again by Neumayr in Denkshriften der Kais. Akad. der Wissensch., Vienna, Vol. L., 1885, where their relations are discussed in connection with that author's paper on the geographical distribution of the Jurassic, to which formation they are referred by him. The formation yielding these fossils, according to M'Clintock, characterizes the west side of the long point on which its existence is indicated on the map, the eastern side of the same point being composed of Carboniferous limestones. In the appendix to M'Clintock's voyage, from which the above notes are extracted, Prof. Haughton discusses questions raised by these fossils at some length. (*Cf.* p. 12 R of these notes.)

Liassic Rocks.

In response to an enquiry as to whether these fossils might not possibly be assigned to the "Alpine Trias"—a question already alluded to in these notes—Prof. Haughton very kindly had casts made of the specimens, which are now in the Dublin Museum. These were forwarded by Mr. Valentine Ball, Director of the museum, to Professors Neumayr, of Vienna, and Waagen, of Prague. Prof. Neumayr's opinion has already been referred to. Prof. Waagen writes that so far as he can judge there cannot be much doubt that *A. M'Clintocki* is a Jurassic species, but rather of Middle Jurassic than of Liassic affinities. "The

Question of the age of these rocks.

* Not Grinnell Land, which lies immediately west of North Greenland, but the smaller island of the same name, to the north-west of North Devon.

4

Prof. Waagen on the fossils.

Avicula [*Monotis*], that also has been found at the same localities, might be Triassic, but just as well it might be Jurassic, and there can be drawn no conclusion from that species. So on the whole, the probability remains that in these high latitudes Jurassic beds are exposed. The Triassic beds described by White, from Idaho, in his Contributions to Palæontology, and later on in the Fortieth Parallel Report, are quite different things, and only the *Avicula* shows any similarity. Such a similarity is, however, of no value whatever."

Further note by Prof. Haughton.

Prof. Haughton further informs me that after Prof. Waagen's letter, of which the above is an extract, reached Dublin, the whole subject was discussed before the Royal Geological Society, and that the concensus of opinion was in favour of Prof. Waagen's views. He adds,—"If this be correct, we have the remarkable fact, that Jurassic forms in the American Arctic Archipelago have more relations to Europe than to America."

I think no apology is required for giving the particulars above quoted, as the subject is a very interesting one. To Prof. Haughton, Mr. Ball, and the other gentlemen mentioned, acknowledgments are specially due for their courtesy in responding so cordially to the enquiries made.

Bathurst Island.

At the second locality above mentioned (the northern extreme of Bathurst Island), Captain Sherard Osborne obtained, from rocks *in situ*, a saurian vertebra, which is described by Prof. A. L. Adams, under the name of *Arctosaurus Osborni*. On this discovery is based the reference of rocks at this place to the Lias (Proc. Royal Irish Acad., 2nd series, vol. ii., 1875.) On Exmouth Island, Sir E. Belcher also found vertebrate remains, ascribed by Sir R. Owen to *Ichthyosaurus*.

Exmouth Island.

Exmouth and some small neighbouring islands in mid-channel, between Grinnell Island and North Cornwall, with Princess-Royal Island* to the south-east, and part of the Grinnell Island coast adjacent to it, are included by a dotted line in one of the maps in Belcher's Last of the Arctic Voyages, as the localities from which, presumably Liassic fossils were obtained in this region. The description shows that the containing rocks occur in inconsiderable thickness overlying the "rubbly limestone," which is proved, by its fossils, to be Carboniferous, and forms the greater part of the coast.

Possible Cretaceous area.

The statement of Belcher (*Op. cit.* vol. i., p. 111), with regard to North Cornwall, that "the ravines are deeply channelled out of a very friable sandstone, and in the bottom were noticed large masses of clay-ironstone, septaria and nodules of iron pyrites," with his description of the prevailing rocks of an island of the Victoria Archipelago, to the eastward, on which he landed, as a dark brown ferru-

* Not Princess-Royal Island of Prince-of-Wales Strait, previously mentioned.

ginous clay, with much ironstone, apparently in concretions (vol. i., p. 271), and the general northerly dip of the Carboniferous limestones of the northern part of Grinnell Island, at angles of about 5°, appear to indicate that there may here be a somewhat extensive development of Mesozoic strata. These, although the Lias only has been recognized by fossil evidence, may not improbably include even Cretaceous beds, like those of similar lithological character in the Mackenzie region. A geological examination of this district would be of great interest.

The existence of Tertiary deposits, classed as Miocene by Heer, in the south-western part of Prince-Patrick Island and north-west part of Banks Land, appears to be established, beyond doubt, by the observations of M'Clintock, M'Clure, and Armstrong. At Ballast Beach, on Banks Land, large quantities of fossil and sub-fossil wood occur, which Prof. Heer refers to the Miocene in his Flora Fossilis Arctica, (vol. i.,) in which the following species are named and described by Cramer:—*Pinus MacClurii*, *Pinus Armstrongi*, *Cupressinoxylon pulchrum*, *Cupressinoxylon polyommatum*, *Cupressinoxylon dubium*, *Betula M'Clintockii*. (*Cf. op. cit.* vol. vi.) Tertiary of Banks Land.

The areas coloured as Tertiary on the accompanying map are copied from those shown on the map in Heer's volume above referred to. It is highly probable, however, from statements met with in the works of the Arctic voyagers, that there are many other outliers of rocks of the same age, holding lignite or fossil wood, particularly on, or in the vicinity of the islands just referred to. It may also be remarked, that while, following Heer, these beds are here referred to as Miocene, no distinct evidence is afforded by the fossil woods that they are newer than the Laramie, which is developed near the mouth of the Mackenzie—a formation much nearer in its relations to the Upper Cretaceous. (*Cf.* p. 12 R.)

Ellesmere Land, Grinnell Land and Neighbouring Coast of North Greenland.

Messrs. Fielden and De Rance, in a paper summarizing the geological results of the Arctic expedition under Sir George Nares (1875-76. Quart. Journ. Geol. Soc., vol. xxxiv., 1878), give a remarkably interesting synopsis of a number of the more important facts connected with the geology of this part of the American Arctic regions. Paper by Messrs. Fielden and De Rance.

After noting the Laurentian system as the fundamental one for the region, and as forming Cape Isabella (lat. 76° 20′), and the entire east coast of Ellesmere Land, they give the name *Cape Rawson beds*, to an important overlying series which occupies the coast Cape Rawson beds.

of Grinnell Land from Scoresby Bay to Cape Cresswell, in latitude 82° 40′ N. These rocks are described as being thrown into a series of sharp folds, with a general west-south-west strike, the beds being often vertical and frequently cleaved. The rocks consist of jet-black slates, with impure limestones, traversed by veins of quartz and chert, and of a vast series of quartzites and grits. They are compared to the gold-bearing series of Nova Scotia, and doubtfully referred to the Huronian system. Their lithological character, however, as compared with Canadian rocks, and in view of the occurrence elsewhere to the north of a great Lower Cambrian series, appears to me to favour their inclusion in that series rather than in the Huronian. Further remarks on this subject will be found on page 9 R of these notes.

Probably Cambrian.

Limestone formation.

A limestone formation, resembling that elsewhere so widely spread in the Arctic regions, is described as characterizing considerable tracts on both the east and west sides of Kennedy Channel and Smith's Sound, and a number of localities, from which collections of fossils were made, are enumerated. A coarse basement conglomerate rests on the granitoid rocks on the south shore of Bache Island, and reappears in other localities, recalling the sandstones found further to the west and south in the same stratigraphical position.

Devonian and Carboniferous.

A small area of Devonian rocks, with a few characteristic fossils, was recognized in Dana Bay (eastern part of north coast of Grinnell Land) being the first distinct notice of such beds in the polar area. The Lower Carboniferous sandstones, so widely distributed in the Arctic Archipelago to the west, were not found in this region, but Carboniferous limestones were recognized in several places along the north coast of Grinnell Land to the west of the Devonian rocks just alluded to. "There would also appear to be a strong likelihood that the limestone continues in a south-easterly direction by way of these mountains [the United States range] across the whole of Grinnell Land, and is connected with the limestones forming the well known synclinal of that formation occupying so large a portion of the Parry Archipelago." (*Cp. cit.* p. 560.)

No Mesozoic rocks were discovered in the more northern lands visited by the expedition under Nares.

Tertiary rocks.

Small outlying areas of Tertiary (Miocene of Heer) are noted as occurring at Water-course Bay, at the entrance to Lady Franklin Sound, and in two places on the north shore of the Sound. Coal is found in these beds in association with black shales and sandstones, and from collections made by Capt. Fielden and Dr. Moss, Prof. Heer describes thirty species of plants closely allied to the Spitzbergen Tertiary flora, and indicating rather colder conditions than are expressed by the character of the Disko Island Tertiary plants. The

coal appears to be an excellent fuel, containing only 2·01 per cent. of water. (See Fielden and De Rance, *Op. cit.*, p. 563; Heer, Flora Fossilis Arctica, vol. v., and Quart. Jour. Geol. Soc., vol. xxxiv., p. 66.)*

The paper above referred to, by Messrs. Fielden and De Rance, is accompanied by a valuable geological sketch-map of Grinnell Land and neighbouring regions, and is followed by Prof. Etheridge's detailed account of the palæontology of the region, which includes general remarks on the bearing of the fossils obtained, and points out the American affinities presented by a number of the forms.

Kennedy Channel. In the American Journal of Science and Arts (2nd series, vol. xl., p. 31.) Prof. F. B. Meek describes a number of Upper Silurian fossils collected by Dr. Hayes, on the west shore of Kennedy Channel between latitudes 79° and 80°. (Latitudes in original, "80° to 81°" erroneous.)

Greely Expedition. Capt. Greely's Expedition (1881 to 1884), though so important in its results from a geographical point of view, has added comparatively little to our geological knowledge of Grinnell Land and the northern coast of Greenland, a fact due to the absence of a geologist and the enforced abandonment of the specimens collected. **Interior of Grinnell Land.** From a careful perusal of Capt. Greely's narrative (Three Years of Arctic Service, 1886) and from information obligingly supplied by him and by Lieut. Brainard, in answer to enquiries made by correspondence, some facts of importance are, however, brought out. The Tertiary coal-bearing formation is evidently much more widely spread in the part of Grinnell Land in the vicinity of Lady Franklin Sound, than the previously quoted map of Messrs. Fielden and DeRance would indicate, though it may probably be regarded as forming detached outliers (which I have not ventured to outline) on the Cape Rawson beds, shown by these authors to characterize the region generally. Bituminous coal was found at Lincoln Bay, half a degree north of the mouth of Lady Franklin Sound, on the east Grinnell Land coast in different parts of the Bellows Valley (which runs inland to the north of the same sound) to the head, and in the neighbourhood of Lake Hazen, to the westward, by Capt. Greely. Lieut. Brainard also describes in an appendix, a fossil forest discovered by him in Archer Fiord, a few miles west of Cape Baird, which, with the associated rocks, is without doubt referable to the Tertiary. Toward the head of Chandler Fiord, (running west from Lady Franklin Sound), Greely mentions high cliffs of "schistose slate" (vol. i. p, 266), and in Ruggles River, the outlet of Lake Hazen, large slabs of "slate'

* For a detailed list of memoirs and reports on the fossil plants of Greenland, etc., to date, see note by Prof. T. R. Jones in "Arctic Manual," 1875, pp. 372-373. The most important coal beds of the vicinity of Disko occur in the Atane, or upper division of the Cretaceous. "Arctic Manual," pp. 426, 430.

which had been used by the Eskimo in building their huts. (vol. i. p. 379.) Brainard speaks of the cliffs of Beatrix Bay, as dark, those of Ella Bay, as very light in colour. These bays constitute the termination of Archer Fiord. He remembers the cliffs on Musk Ox Valley to have been again of dark colours. Respecting Greely Fiord, on the west coast of Grinnell Land, he quotes from his diary—"On the north shore of this fiord, the line of cliffs present a feature of marked peculiarity Horizontal lines or strata of different colours run uniformly for miles along their face." He adds, "The predominating colours in these lines and of the cliffs was a pale yellow. On the south side where we were encamped, the cliffs were of about the same colour as those spoken of above, but the strata were not noticed. They were from 1500 to 1800 feet above the sea-level, and presented a castellated appearance. Fossils in great numbers were found here."

Greely Fiord.

Distribution of rocks.

These observations appear to me to establish the probability of the extension of the Cape Rawson beds, or of rocks like them, westward, well toward the head of Greely Fiord, while a nearly horizontal fossiliferous (limestone?) formation forms the sides of the fiord itself. Taken in connection with the belief, stated by Fielden, that the United States Range, running toward the fiord from the north coast of Grinnell Land, marks the strike of the Carboniferous limestones, I have ventured to designate the shores of the fiord as composed of these rocks, though the description would apply equally well to Silurian limestones, such as those of the vicinity of Hayes Sound to the southward.

Silurian fossils.

A number of fossils recognized by comparison with cuts in Dana's Geology as Silurian, were collected at Cape Craycroft, a few miles south of the entrance to Lady Franklin Sound (vol. ii., p. 25 and Appendix xv.) They were obtained from rock *in situ*, at the base of high cliffs composed of sandstone interstratified with a lighter rock.

Ellesmere Land.

Of the west coast of Smith's Sound from Victoria Head, beyond the 79th, to Cape Isabella (above referred to) near the 78th degree of latitude, as well as that part of the coast running southwardly to Jones Sound, Dr. P. C. Sutherland remarks:—"From its greater height in many parts than the adjacent, opposite shore, and also from its ragged, and in some places even pinnacled, contour, thus resembling the coast of Cape Farewell, it probably consists for the most part of crystalline rocks." (Quart. Journ. Geol. Soc., vol. ix., 1853, p. 299.) Though the coast-line, where formed of the Cape Rawson beds, is also high and rough, it appears not improbable that Dr. Sutherland is correct in his conjecture above quoted. He further describes the eastern part of Jones Sound and Cobourg and neighbouring islands as presenting a similar rough and high contour.

East side of Smith's Sound.

Our knowledge of the geological features of the east coast of Smith's

Sound is unfortunately but fragmentary. Dr. Sutherand's description of that part of the coast extending from Cape York northward, for over two degrees of latitude, leads to the belief that it is characterized throughout by Teritary rocks like those of Disko, including as at that place both stratified volcanic materials and ordinary sandstones. Dr. Sutherland writes:—"At Cape York, lat. 76°, and also at Cape Atholl, thirty to forty miles further north, although differing in outline, owing to the glacial accumulations, from Disko Island and other well-known parts of the coast to the southward, the rocks can be referred with certainty to the same trappean formation." To the north of Cape Atholl, the rocks forming the coast and adjacent islands were abserved to be distinctly stratified, and in general to be either horizental or undulating at low angles. Where examined, the rocks were found to be sandstones, interstratified with volcanic materials. (Quart. Journ. Geol. Soc., vol. ix., pp. 297-298.) Southern part.

It must be confessed, however, that our knowledge of this part of the Greenland coast is extremely imperfect, and the geological colouring of the map is here little more than conjectural. Prof. Haughton states that Cape York "is composed of a fine-grained granite, consisting of quartz, white felspar with minute specks of a black mineral of pitchy lustre, composition not yet determined." Of the coast to the north he writes "At Wolstenholme Sonnd (lat. 77° N.), the granitoid rocks of Greenland become converted into mica-slate and actinolite-slate of a remarkable character," the two rocks passing into each other by an almost insenible gradation. "In the low ground between Wolstenholme and Whale Sounds [thirty-seven miles further north], the granite rocks cease, and are covered by deposits of fine red gritty sandstone, of a banded structure, and a remarkable coarse white conglomerate. The boundary between these formations is also marked by the development of masses of dolerite and clayey basalt. Carey's Islands, 76° 40′ N., lie to the west of Wolstenholme Sound, and are composed of a remarkable gneissose mica-schist, formed of successive thin layers of quartz granules, containing scarcely any felspar, and layers of jet-black mica, with occasional facets of white mica. This mica-schist passes into a white gneiss, composed of quartz, white felspar, and black mica, penetrated by veins, coarsely crystallized, of the same minerals. Yellow and white sandstones are also found in small quantity on the islands, reposing upon the graitoid rocks." (Appendix to M'Clintock's voyage, pp. 374, 375.) It may be conjectured that Archæan and Tertiary rocks occur on this coast in relations similar to those which they hold in the vicinity of the Disko, though it must be admitted as possible that the red sandstones, above described, are, like those of Bache Island, (p. 52 R) on the west side of the strait, at the base of the Silurian. Notes by Prof. Haughton. Possible relations of rocks.

Northern part. Further northward "the rocks of the coast between Rensselaer Harbour and the great Humboldt glacier [in Peabody Bay], were stratified limestone, red sandstone, felspathic and often porphyritic granite, passing into gneiss, and in some places trap. The limestone and sandstone formed lofty cliffs, averaging 900 feet in height, Hakluyt Island in latitude 77° 20′, presents on the coast a coarse sandstone in nearly horizontal strata, while in the back country, the rocks were in broken pyramidal shapes, appearing to be 'greenstone.'" (Results of Kane's Expedition, Am. Journ. Sci. and Arts, 2nd series, vol. xxiv., 1857, p. 248.)

North coast of Greenland. The Upper Silurian limestone is stated, further north, to have been found along the whole west coast of North Greenland from the Humboldt glacier as far as the expedition of Captain Hall in the 'Polaris' extended. (Nature, vol. ix., 1874, p. 405.)

The western part of the northern coast of Greenland, beyond Robeson Channel, is shown by Messrs. Fielden and De Rance, as composed of beds of the Cape Rawson series. For the coast east and north of that thus described, the following facts obtained by the Greely expedition constitute all the information available.

Of the beds of Lockwood Island, near the furthest north and east point reached on the Greenland coast, Capt. Greely writes:—"Brainard and Lockwood both concurred in the opinion that the geological structure of Lockwood Island (83° 24′) and those south, was the same as around Discovery Harbour." Lockwood's published sketches and descriptions show no evidence of the existence of horizontally stratified rocks in this part of Greenland. It is described as being cut up by numerous and deep fiords with bold sides, or inlets with "no visible land at the head of several of them, very much like immense canals, and give the whole coast the appearance of Greenland, between Upernivik and Disko," (*Op. cit.* vol. i. p. 348). These statements render it probable that this coast is formed by some ancient rocks of a massive character, most probably resembling those of the Cape Rawson series rather than those of the Archæan, as granitic or gneissic rocks would, probably, have evidenced their nature even to non-geological observers and received special notice. The indications afforded are, however, too vague to justify the geological colouring of the coast on the map.

Direction of Ice Movement in the Glacial Period.

Observations on glacial phenomena. As stated in the introductory pages of these notes, no attempt is here made to include an account of the superficial deposits, which are nevertheless extensively developed in the extreme northern part of the continent, and on some of the Arctic islands. Interesting obser-

vations on these deposits, particularly in regard to the height at which fossiliferous Pleistocene beds occur above the sea-level, are given by many of the explorers of the region, but most of the explorations were performed before phenomena of the glacial period had attracted the close attention of geologists, and the rock striation, which is doubtless to be found almost everywhere, and would give important information as to the direction of ice movement, has, in consequence, seldom been noted. Some facts bearing on the direction of ice movement during the glacial period, derived from the observed distribution of boulders and rock fragments, are, however, so important that they may be briefly adverted to.

Sir J. Richardson's observations in the region of the Mackenzie are sufficient to indicate the general direction of transport of erratics westward from the Laurentian plateau, out over the flat-lying limestone country, but whether the direction trended to the south or north of west, remains indeterminate. Erratics of Mackenzie valley.

Along the Arctic coast, and among the islands of the archipelago, there is a considerable volume of evidence to show that the main direction of movement of erratics was *northward.* Thus, boulders of granite, supposed by Prof. Haughton to be derived from North Somerset, are found 100 miles to the north-eastward, (Appendix to M'Clintock's voyage, p. 374), and pebbles of granite, identical with that of Granite Point, also in North Somerset, occur 135 knots to the north-west, (*Op. cit.* p. 376). The east side of King-William Land is also said to be strewn with boulders like the gneiss of Montreal Island, to the southward (p. 377). Prof. Haughton shows the direction and distance of travel of some of these fragments by arrows on his geological map of the Arctic Archipelago, and reverts to the same subject on pages 393, 394, pointing out the general northward movement of ice indicated, and referring the carriage of the boulders to floating ice of the glacial period. Northward movement of erratics. Erratics of Arctic Archipelago.

Near Princess-Royal Island, in Prince-of-Wales Strait, and also on the coast of Prince-of-Wales Island, the copper said to be picked up in large masses by the Eskimo, (DeRance, Nature, vol. xi., p. 492), may be supposed to be derived from the Cambrian rocks of the Coppermine River region to the south, as it is not probable that it occurs in place anywhere in the region of horizontal limestone where it is found.

Dr. Armstrong, previously quoted, notes the occurrence of granitic and other crystalline rocks, not only on the south shore of Baring Land, but also on the hills inland. These, from what is now known of the region, can scarcely be supposed to have come from elsewhere than the continental land to the southward.

Erratics of Smith's Sound.

In an account of the scientific results of the 'Polaris' expedition, (Nature, vol. ix), it is stated of the west coast of Smith's Sound, north of the Humboldt glacier, that "wherever the locality was favorable, the land is covered by drift, sometimes containing very characteristic lithological specimens, the identification of which with rocks of South Greenland was a very easily accomplished task. For instance, garnets of unusually large size were found in lat. 81° 30′, having marked mineralogical characters by which the identity with some garnets from Tiskernaces was established. Drawing a conclusion from such observations, it became evident that the main line of the drift, indicating the direction of its motion, runs from south to north." It should be stated, however, that Dr. Bessels, who accompanied the 'Polaris' expedition, regards these erratics as certainly not transported by glaciers, but by floating ice, and as showing that the current of Davis Strait was formerly to the north, and not to the south as at present. (Bull. Soc. Géog., Paris, vol. ix., 1885, p. 297.)

Glaciation of Hudson Bay and Strait.

It may further be mentioned as bearing on the general question here referred to, that Dr. Bell has found evidence of a northward or north-eastward movement of glacer-ice in the northern part of Hudson Bay. (Annual Report Geol. Survey of Canada, 1885, p. 14, DD), with distinct indications of eastward glaciation throughout Hudson Strait. (Report of Progress, Geol. Survey of Canada, 1882-84, p. 36, DD).

General conclusions.

The facts so far developed in this northern part of the continent and in the Arctic islands, thus point to a movement of ice outward in all directions from the great Laurentian axis or plateau, which extends from Labrador round the southern extremity of Hudson Bay to the Arctic Sea, rather than to any general flow of ice from the vicinity of the geographical pole southward.

List of the Principal Works and Papers Consulted in the Preparation of the Geological Map of the northern Part of the Dominion of Canada.

In the following list are included the full titles and dates of publication of works and papers affording geological information which has been embodied in the foregoing pages or in the accompanying map. Works relating to the same region, but from which no geological facts of importance have been obtained, are excluded, and no references are given to authorities on the geology of the Greenland coast south of Cape York. The order observed is in the main that of the date of publication.

Notice relative to the Geology of the Coast of Labrador, by Rev. Mr. Steinhauer. Transactions of the Geological Society, vol. ii., 1814.

A Voyage of Discovery, for the Purpose of Exploring Baffin's Bay, etc., by Sir John Ross, in 1818, London, 1819. Geological appendix by Dr. McCulloch.

Narrative of a Journey to the Shores of the Polar Sea in the years 1819-22, by Capt. J. Franklin, London, 1823. Appendix i., by J. Richardson, M.D.

Journal of a Second Voyage for the Discovery of a North-West Passage, etc., 1821-23, by Captain Parry, London, 1824.

A Supplement to the Appendix to Capt. Parry's Voyage for the Discovery of a North-West Passage in the years 1819–20 (Natural History) London, 1824. Notes on Rock Specimens by Charles Koning.

A Brief Account of an Unsuccessful Attempt to reach Repulse Bay, etc., by Capt. G. F. Lyon, London, 1825.

Journal of a Third Voyage for the Discovery of a North-West Passage, etc., by Capt. W. E. Parry, London, 1826. Appendix by Prof. Jameson on Geology of Countries discovered during Capt. Parry's Second and Third Expeditions.

Narrative of a Second Expedition to the Shores of the Polar Sea in the years 1825-27, by Capt. J. Franklin, London, 1828. Appendix i., by J. Richardson.

Narrative of Discovery and Adventure in the Polar Seas and Regions, by Professors Leslie, Jameson and Hugh Murray, Edinburgh, 1830.

Narrative of a Second Voyage in Search of a North-West Passage, etc., 1829-33, by Sir John Ross, London, 1835. Appendix on Geology, by Sir J. Ross.

Narrative of the Arctic Land Expedition, etc., 1833-35, by Captain Back, London, 1836. (See also Journ. Royal Geog. Soc., vol. iv., 1836.)

Narrative of an Expedition in H.M.S. 'Terror,' 1836-37, by Captain Back, London, 1838.

Narrative of the Discoveries on the North Coast of America, etc., 1836-39, by Thomas Simpson, London, 1843.

Some account of Peel River, North America, by A. K. Isbister, Journ. Royal Geog. Soc., London, vol xv., 1845, p. 332.

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Arctic Searching Expedition, a Journal of a Boat Voyage through Rupert's Land and the Arctic Sea, by Sir J. Richardson, London, 1851.

Journey from Great Bear Lake to Wollaston Land and Explorations along the South and East Coast of Victoria Land, by Dr. J. Rae, Journ. Royal Geog. Soc., vol. xxii. 1852.

Journal of a Voyage in Baffin's Bay and Barrow Straits in 1850-51, by P. C. Sutherland, M.D., London, 1852. Geological appendix, by J. W. Salter.

On the Geological and Glacial Phenomena of the Coasts of Davis' Strait and Baffin's Bay, by P. C. Sutherland, M.D., Quart. Journ. Geol. Soc., vol. ix., 1853, p. 296.

On Arctic Silurian Fossils, by J. W. Salter, Quart. Journ. Geol. Soc., vol. ix., 1853, p. 312.

A Summer Search for Sir J. Franklin, by Capt. Inglefield, 1853. [Contains a geological appendix. I have seen only the notices derived from this work in the "Arctic Manual" of 1875.]

The Last of the Arctic Voyages, etc., 1852-54, by Sir E. Belcher, London 1855. Appendix by J. W. Salter on Arctic Carboniferous Fossils, and by Prof. Owen, on Remains of Ichthyosaurus, from Exmouth Island. (See also notes on the Discovery of Ichthyosaurus and other Fossils in the Late Arctic Searching Expedition, by Capt. Sir E. D. Belcher. Report of British Association, 1855.)

On Some Additions to the Geology of the Arctic Regions, by J. W. Salter. Report of the British Association for the Advancement of Science, 1855.

Further Papers Relative to the Recent Arctic Expeditions in Search of Sir John Franklin, etc. London, Government, 1855.

On the Geology of the Hudson's Bay Territories and of Portions of the Arctic and North-Western Regions of America, by A. K. Isbister, Quart. Journ. Geol. Soc., vol. xi. (Also reprinted, without map, in Am. Journ. Sci. and Arts, second series, vol. xxi., 1856, p. 313.)

The Discovery of a North-West Passage by H.M.S. 'Investigator,' Capt. R. M'Clure, 1850-54, London, 1857. Geological appendix by Sir R. Murchison.

A Personal Narrative of the Discovery of the North-West Passage, by A. Armstrong, M.D., late surgeon and naturalist to H.M.S. 'Investigator,' London, 1857.

Arctic Explorations by Dr. E. K. Kane, Am. Journ. Sci. and Arts, second series, vol. xxiv., 1857, p. 235.

Map of the North-West Part of Canada, etc., by J. Devine, Toronto, 1857. (Geological indications.)

Report from the Select Committee on the Hudson's Bay Company, etc, London, Government, 1857. (Geological map.)

A Narrative of the Discovery of the Fate of Sir John Franklin, by Captain M'Clintock, London, edition of 1859. Geological appendix by Prof. Samuel Haughton. (Geological map.) [Notes on the geological results of M'Clintock's voyages were first published in the Journ. Royal Dublin Society, vol. i., 1857, and vol. iii., 1860. The first mentioned paper is accompanied by a geological map which formed the basis of that subsequently produced in connexion with the Appendix to M'Clintock's "Narrative." I have seen only the abstract of these papers by Prof. Haughton, which appears in the "Arctic Manual" of 1875.]

Report of the Assiniboine and Saskatchewan Exploring Expedition, by H. Y. Hind, Toronto, 1859.

Notes on the Geology of the Coast of Labrador, by Oscar M. Lieber. Appendix No. 42, U. S. Coast Survey, 1860.

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Report on the Geological and Mineralogical Specimens collected by C. F. Hall in Frobisher Bay, Am. Journ. Sci. and Arts, second series, vol. xxxv., 1863.

Preliminary notice of a small collection of Fossils found by Dr. Hayes on the West Shore of Kennedy Channel, by F. B. Meek, Am. Journ. Sci. and Arts, second series, vol. xl., 1865, p. 31.

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Remarks on the Geology of the Mackenzie River, with Figures and Descriptions of Fossils from that Region, in the Museum of the Smithsonian Institution, etc., by F. B. Meek, Chicago Academy of Sciences, 1868.

Flora Fossilis Arctica, Dr. Oswald Heer, vol. i., 1868.; vol. ii., 1871, Fossile Flora des Baren Insel; vol. v., 1878, Die Miocene Flora des Grinnell-Landes; vol. vi., 1880, Beiträge zur Miocenen Flora von Nord-Canada.

Scientific Results of the 'Polaris' Arctic Expedition. Nature, vol. ix., 1874, p. 404.

A Whaling Cruise to Baffin's Bay, etc., by A. H. Markham, London, 1874. Appendix C., List of Geological Specimens, by R. Etheridge.

Manual of the Natural History, Geology and Physics of Greenland and neighbouring Regions, etc., edited by Prof. T. R. Jones, London, 1875. [This volume, prepared for the use of Nares' expedition under the direction of the Arctic Committee of the Royal Society, contains reprints of portions of several of the works and papers above referrod to, with occasional important remarks and memoranda by the editor.]

Arctic Geology, by C. E. De Rance. Nature, vol. xi., 1875. (Geological map.)

On a Fossil Saurian Vertebra from the Arctic Regions, by Prof. A. L. Adams, Proc. Royal Irish Acad., second series, vol. ii., 1875.

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L'Expedition Polaire Américaine, sous les ordres du Capitaine Hall. Letter by Dr. E. Bessels. Bul. Soc. Géog., Paris, vol. ix., 1875, p. 297.

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Palæontology of the Coasts of the Arctic Lands, visited by the late British Expedition, etc., by R. Etheridge, Quart. Journ. Geol. Soc., vol. xxxiv., 1878, p. 568. (Abstracts of this and the foregoing paper appear in Am. Jour. Sci. and Arts, third series, vol. xvi., p. 139.)

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Narrative of the Second Arctic Expedition made by C. F. Hall, Washington, Government, 1879. Appendix iii., by Prof. B. K. Emerson.

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Reports by Dr. R. Bell in Reports of Geological Survey of Canada, 1877-78, 1879-80, 1882-84, and 1885. Also, The Geology of Hudson's Bay and Strait, in the Report of the Hudson's Bay Expedition, 1885. Department of Marine, Ottawa; Geology and Economic Minerals of Hudson's Bay and Northern Canada (abstract) in Trans. Royal Soc. Can., vol. ii., sect. iv., p. 241.

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GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

STATISTICAL REPORT

ON THE

PRODUCTION, VALUE, EXPORTS AND IMPORTS

OF

MINERALS

IN CANADA

DURING THE YEAR 1886 AND PREVIOUS YEARS;

BY

EUGÈNE COSTE, M.E.,
Diplomé of "l'Ecole Nationale Supérieure des Mines de Paris, France."
Mining Engineer to the Geological Survey of Canada.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.

1887.

To ALFRED R. C. SELWYN, C.M.G., LL.D. F.R.S.,

Director of the Geological and Natural History Survey of Canada.

SIR.—I have the honor to submit herewith a statistical report on the mineral production of the Dominion of Canada during the calendar year 1886.

As the value of such reports is greatly enhanced by the promptness with which they are published, it is hoped that the report for 1887 will be ready at a much earlier date next year. The delay that has occurred in the present instance has been unavoidable, and is partly due to its being the first report of the kind, and partly to a good deal of my time having been occupied in 1886 by the examination and mapping of the Madoc and Marmora gold and iron-bearing districts of Ontario.

I am, Sir,

Your obedient servant,

E. COSTE.

JULY 15th, 1887.

NOTE.—Throughout this report the ton employed is of 2,000 lbs and the year the calendar year unless otherwise specified.

The fiscal year referred to in some tables begins on the first of July.

REPORT

ON THE

MINERAL STATISTICS

OF THE

DOMINION OF CANADA.

DURING THE YEAR 1886 AND PREVIOUS YEARS.

INTRODUCTORY.

I feel much obliged and thankful for the uniform courtesy shown us in the undertaking of this work, but as it would be too long to mention the names of all those who have kindly responded to our enquiries, I shall only testify in a general way to the very cordial co-operation and hearty assistance obtained in almost every case. Special thanks are, however, gratefully given to the Departments of Mines of Nova Scotia and British Columbia, from which all the returns of their respective provinces were obtained in advance. Special credit is also due to Mr. E. D. Ingall, my former colleague in this branch of the work of the Survey, but who has since been entrusted with the monographing of the various mining regions of the Dominion; and thanks are tendered him for his share in the organization of this work. Acknowledgments.

Special mention must also be made of the prompt and intelligent help afforded me by my assistant, Mr. H. P. Brumell, of the Geological Survey. Several days of tedious work having often been necessary for the preparation of a single table; the final result therefore gives no idea of the amount of labour that has been required.

The statistics of the quantities of minerals produced and of the value of each product, have been the special objects of all our enquiries. All technical information and descriptive matter of every kind which has been collected, bearing upon the present condition of the different

mining industries, or upon the history of the past operations in the various mining districts, has been carefully classified and recorded. It was intended at first, as mentioned in our circulars, to embody part of this information in the present report, but this was soon found to be impossible until more complete researches and studies, and personal examination had been made in the different districts. Under the circumstances, unavoidable gaps will be noticed; they have been pointed out wherever known, so as not to mislead as to the real value of the returns, and with the view of suggesting in the future assistance from those interested in the industries of which the present returns are unfortunately incomplete. This is specially true for the products, building-stones, bricks and lime, of which, on account of the very short time at our disposal to get correct lists of all the numerous persons interested in these industries, it has been possible to give only a compilation of such statistics as could be obtained; we were not even able to estimate fairly what the proportion of the quantities returned bore to the total production.

Ton and year adopted through report.

The general rule of taking the ton of 2,000 lbs. as the unit of quantity, has been adopted, and unless otherwise specified, the years are understood to be calendar years. This applies also to the tables of exports and imports, which were compiled from the books of the Customs Department at Ottawa, kindly placed at our disposal, with the greatest courtesy, by the Honorable the Minister and Mr. Barry, Chief Clerk of the Statistical branch of that Department. The exports and imports of some items have not been obtained, because separate returns of them are not kept by the Department of Customs, but changes in the future entries have been suggested to meet this, and have been readily assented to.

Records of present and past mining operations.

The endeavors to collect for preservation, in this office, all documents, plans and sections, referring to the extent and nature of the workings of the different mines of the country, will be continued, and already a good beginning has been made. Efforts will also be continued to ascertain, as accurately as possible, the history of all past mining operations, and information on this point is again particularly solicited.

SUMMARY OF THE MINERAL PRODUCTION OF CANADA IN 1886.

Name of Product.			1886. Quantity.	1886. Value. (a)
Antimony ore		tons	665	$31,490
Arsenic		"	120	5,460
Asbestus		"	3,458½	206,251
Charcoal		bush.	901,500	54,000
Chromic iron ore		tons.	60	945
Coal		"	2,091,976	5,017,225
Coke		"	35,396	101,940
Copper (fine, contained in ore)		lbs.	3,505,000	354,000
Gold		ozs.	76,879	1,330,442
Graphite		tons.	500	4,000
Grindstones		"	4,020	46,545
Gypsum		"	162,000	178,742
Iron ore		"	69,708	126,982
Manganese ore		"	1,789	41,499
Mica		lbs.	20,361	29,008
Mineral pigments	Baryta	tons.	3,864	19,270
	Terra alba	"	4,000	24,000
	Whiting	bbls.	400	600
	Ochre	tons.	350	2,350
Molybdenum (c)		lbs.	150	156
Petroleum (d)		bbls.	486,441	437,797
Phosphate		tons.	20,495	304,338
Pig iron (incomplete return)		"	22,192	237,768
Pyrites		"	42,906	193,077
Salt (e)		"	62,359	227,195
Silver (b)			....	209,090
Soapstone		tons.	50	400
Structural Materials.	Granite	"	6,062	63,309
	Marble and serpentine	"	501	9,900
	Slate	"	5,345	64,675
	Flagstones	sq. feet.	70,000	7,875
	Building-stones	cub. yds.	165,777	642,509
	Lime	bush.	1,535,950	283,755
	Sands and gravels	tons.	646,552	143,641
	Bricks	M.	139,345	873,600
	Tiles	M.	12,416	142,617
	Miscellaneous clay products		....	112,910
Total			....	$10,529,361

(a) These figures give full values at the mines, quarries, etc.

(b) Port Arthur district production, plus about $167,000 estimated silver contained in the copper pyrites of the Capelton district.

(c) Sold mostly as cabinet specimens.—Value for manufacturing purposes from 50 to 60 cts. a pound.

(d) Crude equivalent of the quantity of refined oils inspected.

(e) In barrels of 280 lbs.=445, 421 bbls.

SUMMARY OF THE VALUE OF MINERALS EXPORTED BY PROVINCES.

Calendar Years.	Ontario.	Quebec.	Nova Scotia.	New Brunswick.	Manitoba.	British Columbia	Prince Ed. Island.	Total.
1873........	$3,200,345*	$219,304	$1,047,445	$218,928	....	$1,271,487	$713	$5,958,222
1874........	955,820	142,208	760,658	233,833	....	1,630,421	454	3,723,394
1875........	657,926	318,055	498,464	117,251	....	2,084,322	626	3,676,644
1876........	949,645	374,868	358,764	104,469	....	1,906,642	832	3,695,220
1877........	437,308	355,270	459,830	153,564	$341	1,719,066	....	3,125,379
1878........	828,669	255,215	385,104	156,903	174	1,652,687	45	3,278,797
1879........	287,109	169,588	296,512	141,228	392	1,552,936	209	2,447,974
1880........	280,488	396,753	712,177	159,990	....	1,352,011	656	2,902,075
1881........	243,598	357,682	606,634	150,984	941	1,403,777	335	2,763,951
1882........	245,195	573,016	775,054	108,119	....	1,222.424	5	2,923,813
1883........	128,935	658,011	793,405	103,165	2	1,648,241	655	3,332,414
1884........	239,323	792,300	885,162	75,367	1,500	1,549,481	193	3,543,826
1885........	185,529	901,645	883,632	83,451	351	1,728,331	125	3,782,964
1886........	186,574	809,661	1,010,240	101,349	1,452	1,720,939	606	3,830,821

* **Large export of oil from Silver Islet.**

This table is taken from the quarterly returns of the Custom's Department, and gives a fair idea of the results of mining operations in the different provinces since 1873, as a great part of the minerals produced is exported.

DISTRIBUTION OF THE VALUE OF THE MINERALS EXPORTED EACH FISCAL YEAR FROM 1874 TO 1886.*

Country to which exported.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Great Britain	383,832	159,464	2,379,472	1,061,201	142,374	265,305	216,867	253,652	311,456	443,831	519,672	485,408	589,832
United States	3,305,319	3,446,332	1,185,005	2,413,525	2,472,979	2,636,334	2,495,624	2,346,529	2,418,[illegible]21	2,198,014	2,505,501	2,898,518	3,115,696
France	657					3,478		5,057	1,200	1,52[illegible]	942	311	3,610
Germany						6,050		3,640	82,560	49,799	1,200	32,870	22,294
Holland	666									650			
Belgium							1,040				3,508	830	
Spain	960	1,400						4,620	330		1,980		
Portugal													860
Sweden and Norway												2,234	322
Denmark									9,000			930	
Russia									750	1,000			
China					8,500	4,025			19,845	29.190			
British East Indies		2,750											2,556
Egypt												2,400	
British West Indies	26,908	32,083	11,768	5,271	1,885	3.569	2,850	3,454	1,853	1,337	7,604	16,077	10,752
Spanish do.	7,300	8,050	8,068	25,998	23,637	30,214	10,396	23,245	35,849	40,270	27,957	7,277	15,926
French do.	101,768	67,485	22,510	3,969				986	1,602	429			
Danish do.						547	950	242		3,2[illegible]			1,936
British Guiana					1,666	1,132	1,037	298	3,285		612	1.241	2,465
St. Dominique	660	405											
Brazil		1,317							700	239			
Argentine Republic												432	
Uruguay									100				
United States of Columbia													3,277
Mexico			11,000	11,750	22,725	20,304	24,750	4 273	14,805	19,820	7,548		1,500
South America	11,183	12,428	6,464	325	1,200	7,731		300					
Central do.												868	
Newfoundland	125,863	133,841	148,314	110,285	117,623	93,264	97,252	94,390	104,537	141,897	133,332	155,251	146,128
St. Pierre	12,100	9,029	10,398	10,313	8,343	7,331	10,989	8,887	8,723	9,651	12,802	17,337	15,315
Labrador					18						93		
Sandwich Islands		1,458	4,768		2,500	3,276	15,600	18,256	40,857	26,979	24.343	19,440	11,428
Australia				1,311	7,897	340			5,900			120	
Gibraltar			35										
British Africa									2,200				236
Morocco													2,754
Russia in Asia													4,200
Italy		1,408											
Total	$3,977,216	$3,878,050	$3,787,802	$3,644,040	$2,816,347	$3,082,900	$2,877,351	$2,767,829	$3,013,573	$2,970,886	$3,247,092	$3,639,537	$3,951,147

* From the Trade and Navigation Returns.

ABRASIVE MATERIALS.

Grindstones.

The total production has not been obtained. The returns which were made to this office give the production as 4,000 tons during the year, valued at the quarries at $46,545. This we believe to represent about four-fifths of the actual production.

By Provinces, the above production is divided in the following manner:—

		Tons.	Value.
New Brunswick	4 quarries in Gloucester County.	2,255	$22,495
Nova Scotia.	1 quarry in Cumberland Co. 1 quarry in Pictou Co.	1,765	$24,050

The exports and imports are given below as well as the imports of emery and pumice stone:—

EXPORTS OF GRINDSTONES.

PROVINCES.	1884.	1885.	1886.
Ontario	$ 298	$	$
Quebec	3	60	1
New Brunswick	16,183	13,404	14,784
Nova Scotia............	11,702	9,142	9,400
Totals..........	$28,186	$22,606	$24,185

IMPORTS OF GRINDSTONES.

PROVINCES.	1885.		1886.	
	Tons.	Value.	Tons.	Value.
Ontario....................	527	$ 7,079	862	$ 9,587
Quebec....................	278	3,032	222	2,718
Nova Scotia...............	...	44	...	69
Manitoba.................	12	384	30	832
British Columbia..........	8	604	18	488
Totals..........	825	$11,143	1,132	$13,694

IMPORTS OF EMERY AND PUMICE STONE.

Emery and pumice stone.

PROVINCES.	1885.	1886.
Ontario..................	$ 7,274	$10,461
Quebec	5,731	3,225
Nova Scotia..............	515	103
New Brunswick	1,189	1,250
Manitoba	5	1
British Columbia.........	25	33
Prince Edward Island.....	30	12
Totals...........	$14,769	$15,085

ANTIMONY.

The total exports of Antimony ore in 1886, were 665 tons, the declared value of which was $31,490. In 1885, the total exports were 756 tons, the declared value of which was $33,250.

In 1886, The Brunswick Antimony Mining Co. of Lake George, York County, New Brunswick, resumed work, which had been suspended since November, 1883.

Preparatory work was also resumed at The South Ham mine, in the province of Quebec, during the summer of 1886. The Rawdon mine, Hants County, Nova Scotia, has been steadily worked since the end of the year 1883.

EXPORTS OF ANTIMONY ORE.

Years	Ontario.		Quebec (a.)		Nova Scotia (b.)		New Brunswick (c)		Manitoba.		Total.	
	Tons.	Value.	Tons.	Value	Tons.	Value.	Tons.	Value.	Tons.	Value	Tons.	Value
1873	..	......	..	..	....	......	30	2,727	..	..	30	2,7[illegible]
1874	..	......	..	..	....	......	..	......	..	..	......	......
1875	..	......	..	..	....	......	..	......	.	..	......	......
1876	..	.....	..	..	....	.....	..	......	..	..	......	......
1877	..	......	..	..	....	......	..	......	..	..	......	......
1878	..	......	71	4,500	....	......	1	24	..	...	72	4,5[illegible]
1879	..	......	8	300	....	......	..	......	..	..	8	300
1880	..	......	..	..	....	......	40	1,948	..	..	40	1,948
1881	..	......	..	..	....	......	34	3,308	..	..	34	3,30[illegible]
1882	..	......	..	..	....	......	323	11,673	..	.	323	11,6[illegible]
1883	..	......	..	..	2	30	163	4,170	..	..	165	4,200
1884	.	......	..	..	483	17,875	..	......	(d) 3	,500	486	19,5[illegible]
1885	(d) 2	3,000	..	..	756	33,250	..	......	..	-	758	36,250
1886	..	......	..	..	645	30,690	20	800	..	..	665	31,49[illegible]
Tot'	2	$3,000	79	$4,800	1,886	$81,845	611	$24,650	3	$1,500	2,581	$115,7[illegible]

South Ham mine production.
(b.) Rawdon mine production.
(c.) Probably all Lake George mines.
(d.) These figures cannot be explained and are probably mistakes.

IMPORTS OF ANTIMONY.

Provinces.	1885.		1886.	
	Pounds.	Value.	Pounds.	Value.
Ontário	41,289	$3,924	41,238	$3,261
Quebec	41,095	3,521	46,470	4,037
Nova Scotia.......	80	9	724	60
New Brunswick...	708	70	76	7
Manitoba....	45	2	1	1
British Columbia..	......	......	77	8
Totals.........	83,217	$7,526	88,586	$7,374

ARSENIC.

The Deloro mine, in the county of Hastings, Ontario, is believed to have been the only mine in Canada producing arsenic, in 1886. 120 tons of refined, practically pure, arsenious oxyde was produced, with a total value at the mine of $5,460. This arsenic is obtained as a by-product in the roasting of the auriferous quartz and mispickel of this mine; a refining operation in a reverbatory furnace is needed. According to the Report of the Mineral Resources of the United States, 1885, published by the United States Geological Survey, there were shipped from this mine to the United States, in 1885, 400 tons of crude (90 to 95 arsenious oxyde) and 40 tons of refined, though it was only in operation from September until the end of the year.

The following table shows the imports of arsenic in 1885 and 1886:—

Provinces.	1885.		1886.	
	Pounds.	Value.	Pounds.	Value.
Ontario	7,567	$219	12,741	$351
Quebec	23,420	670	12,828	533
Nova Scotia	3,149	116	2,412	85
New Brunswick	300	16	....	....
Manitoba	25	1	200	10
British Columbia	60	9	....	....
Totals	34,521	$1,031	28,181	$979

ASBESTUS.

The total quantity shipped in 1886 has been 3,458¼ tons, valued at $206,251 at the mines. This is an increase over 1885 of 1,018 tons, and $63,810. These returns were obtained directly from the mines, which are all situated in the Eastern Townships, province of Quebec, principally at Thetford and Coleraine. The yearly shipments since the time the first mine was opened in 1878 have also been compiled from direct returns, and are given in the following table, which illustrates the steady and very rapid growth of the industry:—

SHIPMENTS OF ASBESTUS FROM CANADIAN MINES.

Years.	Tons.	Value.
1879	300	$19,500
1880	380	24,700
1881	540	35,100
1882	810	52,650
1883	955	68,750
1884	1,141	75,097
1885	2,440½	142,441
1886	3,458¼	206,251
Totals	10,024½	$624,489

COAL.

Summary.

The total quantity of bituminous coal which has been raised from the mines in Canada during the year 1886, is 2,091,976 tons of 2000 lbs., valued at $4,017,225 at the mines. To this must be added a small unknown quantity from New Brunswick, the returns of which have not been obtained, on account of the desultory character of coal mining in that province.

The total exports of coal of all kinds during 1886 were 598,146 tons, of which 78,443 tons were foreign coal previously imported.

The imports for the year 1886 amounted to:—975,528 tons of anthracite; 1,024,702 tons of bituminous coal and 13,542 tons of coke.

Compared with that of 1885, the total production of Canada shows an increase in 1886 of about 140,000 tons and an increased spot value of about $200,000.

In 1885, the total exports were 498,940 tons, of which 71,003 tons were imported coal.

Production by Provinces.

The coal producing districts of Canada are in Nova Scotia, in British Columbia, and in the North-west Territory; a small quantity is also mined in New Brunswick around Grand Lake, in Queen's and Sunbury counties.

North-west Territory.

The production of the mines in the North-west Territory was obtained through direct returns very willingly sent, the only mine not heard from being the Medicine Hat Mine. It amounted in 1886 to a little more than 43,000 tons, the Canadian Anthracite Coal Co., near Banff, N.W.T., having only done preparatory work during the latter part of that year with a force of 75 men.

The statistics of the production for the two provinces of Nova Scotia and British Columbia were kindly furnished us by the Departments of Mines of these provinces.

Nova Scotia.

Tables A, B, C & D, made up from tables sent us by Mr. Gilpin, the Inspector of Mines of Nova Scotia, give the details of the production and of the sales of coal in that province in 1886.

Table E, compiled from the reports of the Department of Mines, gives the yearly production since 1870.

PRODUCTION, SALES AND COLLIERY CONSUMPTION OF COAL IN NOVA SCOTIA DURING THE YEARS 1886, 1885, 1884 AND 1883.

TABLE A.

Period.	Production.	Sales.	Colliery Consumption.
1886—First quarter. Tons.	232,904	171,421	41,475
1886—Second do "	454,309	399,101	39,929
1886—Third do "	599,243	590,971	36,652
1886—Fourth do "	396,468	377,011	41,186
Totals..	1,682,924	1,538,504	159,512
1885.......... " ..	1,514,470	1,405,051	142,939
1884.......... " ..	1,556,010	1,413,048	130,781
1883.......... " ..	1,593,259	1,453,226	125,383

DISTRIBUTION OF NOVA SCOTIA COAL SOLD DURING THE YEAR 1886.

TABLE B.

Market.	Tons.
Nova Scotia:—	
Transported by land	303,950
" by sea.............	211,515
Total.......	515,465
New Brunswick.....................	197,028
Newfoundland.....................	80,053
Prince Edward Island...............	55,068
Quebec...........................	603,413
West Indies.......................	12,728
United States.....................	73,923
Other countries....................	827
Total.......	1,538,505

Coal Trade by counties in Nova Scotia during the year 1886.

Table C.

Year 1886.	Cumberland.		Pictou.		Cape Breton.		Inverness.		Totals.	
	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.
First Quarter	103,664	96,827	80,085	67,534	48,937	7,355	219	205	232,905	171,4[illegible]
Second "	112,418	106,330	123,630	103,960	218,261	188,810	....	....	454,309	399,10[illegible]
Third "	137,959	124,920	145,711	138,341	315,572	327,710	....	....	599,242	590,9[illegible]
Fourth "	148,419	138,640	115,156	103,473	132,893	134,898	....	....	396,468	3[illegible]
Totals.	502,455	466,217	464,582	413,309	715,668	658,773	219	205	1,682,924	1,538,50[illegible]

Production of Coal in Nova Scotia by Collieries during 1886.

Table D.

	Colliery.	Seam.	Tons.
Cumberland Co.	Chignecto	North	10,246
	Joggins	Joggins	24,912
	Lawrence		56
	Springhill	Main North and South	466,781
	Scotia		460
	Acadia } Acadia Comp'ny	Acadia	110,758
	Albion } Acadia Comp'ny	Third and McGregor	87,144
	Vale } Acadia Comp'ny	McBean and Six Feet	143,963
	Intercolonial	Acadia	121,518
	New Glasgow		1,199
Cape Breton Co.	Barachois	Lingan	98
	Blockhouse	Blockhouse	5,671
	Bridgeport	Phelan	16,065
	Caledonia	do.	81,547
	Francklyn	Sydney	2,236
	Glace Bay	Harbor	37,388
	Gowrie	Gowrie	106,744
	International	Harbor	132,305
	Lingan	Lingan	19,811
	Ontario	Phelan	9,630
	Reserve	do.	91,596
	Sydney	Sydney	156,403
	Victoria	Victoria	56,174
Inverness Co.	Broad Cove		118
	Ross		101
		Total	1,682,924

YEARLY PRODUCTION OF COAL IN NOVA SCOTIA SINCE 1870.

TABLE E.

YEAR.	TONS.
1870	700,861
1871	754,031
1872	986,664
1873	1,117,643
1874	977,446
1875	874,905
1876	794,803
1877	848,395
1878	863,081
1879	882,863
1880	1,156,635
1881	1,259,182
1882	1,529,708
1883	1,593,259
1884	1,556,010
1885	1,514,470
1886	1,682,924
Total...	19,152,880

British Columbia.

The following table F is compiled from figures received from the Minister of Mines of British Columbia, and shows the details of the coal trade there in 1886.

COAL TRADE OF BRITISH COLUMBIA DURING THE YEAR 1886.

TABLE F.

Name of colliery.	Coal raised.	Sold for home consumption.		Sold for exportation.		On hand 1st January 1886.		Unsold, including coal in stock Jan. 1st 1887.		Number of men employed.
	Tons.	Tons	cwt.	Tons	cwt.	Tons	cwt.	Tons	cwt.	
Nanaimo....	112,761	33,260	15	79,637	8	1,019	13	882	10	490
Wellington..	185,846	52,300		144,526		31,691		20,711		618
E. Wellington	28,029	427		25,042		1,500		4,060		161
Totals..	336,836	85,987	15	249,205	8	34,210	13	25,653	10	1,2

Table G shows the yearly output since 1874; the figures are taken from the reports of the Minister of Mines of British Columbia.

PRODUCTION OF COAL IN BRITISH COLUMBIA FROM 1874 TO 1886 INCLUSIVE.

TABLE G.

Year.	Tons.
1874	81,000
1875	110,000
1876	139,000
1877	154,000
1878	171,000
1879	241,000
1880	268,000
1881	228,000
1882	282,000
1883	213,000
1884	394,070
1885	365,000
1886	326,636

New Brunswick.

The only official statistics of the production of coal in New Brunswick available, are those of the Census Returns, which give:—

Census year ending 2nd April, 1871.	Coal	4,502 tons.
	Albertite	9,000 "
Census year ending 4th April, 1881.	Coal	6,221 tons.
	Albertite	18,368 "

Imports and exports.

The following tables, 1 and 2, show the imports of coal, coke, coal-tar and pitch, and 3, 4 and 5 the exports of coal. They were compiled from figures furnished by the Bureau of Statistics of the Customs' Department. The exports of coal, the produce of Canada, from other provinces than those for which tables are given, are very small, but Ontario, Quebec and New Brunswick export some imported coal to the extent in 1886 of:—

	Tons.	Declared value.
Ontario	49,469	$119,853
Quebec	20,342	38,092
New Brunswick	8,610	33,038

IMPORTS OF COAL & COKE DURING THE YEARS 1885 & 1886.

TABLE 1.

1885.

Provinces.	Anthracite.		Bituminous Coal.		Coke.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Nova Scotia	22,855	$ 74,161	2,661	$ 10,871	......	$......
P. E. Island	1,891	6,231	99	206	......	......
New Brunswick	38,882	130,620	6,618	14,997	......	......
Quebec	254,744	934,629	100,414	183,078	1,682	5,118
Ontario	627,263	2,749,112	865,196	2,621,107	9,860	33,681
Manitoba	12,196	61,256	4	35	34	237
British Columbia	258	3,113	612	4,223	253	1,041
Totals	958,089	$3,959,122	975,604	$2,834,517	11,829	$40,077

1886.

Provinces.	Anthracite.		Bituminous Coal.		Coke.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Nova Scotia	18,803	$ 59,550	1,243	$ 5,963	......	$......
P. E. Island	1,747	4,975	36	71	......	......
New Brunswick	34,845	111,260	8,922	17,535	2	11
Quebec	267,286	957,740	75,864	136,468	2,132	7,510
Ontario	649,384	2,755,294	937,988	2,541,140	11,140	38,406
Manitoba	3,437	15,800	60	289	163	1,150
British Columbia	26	407	589	3,838	105	364
Totals	975,528	$3,905,026	1,024,702	$2,705,304	13,542	$47,441

IMPORTS OF COAL TAR AND COAL PITCH.

TABLE 2.

Provinces.	1885.		1886.	
	Barrels.	Value.	Barrels.	Value.
Ontario.............	6,534	$8,918	6,732	$10,716
Quebec	5,796	7,589	8,031	13,292
Nova Scotia	4,062	3,056	4,818	4,075
New Brunswick......	1,295	2,260	1,869	4,209
British Columbia.....	28	136	18	108
Prince Edward Island.	497	889	304	667
Totals...........	18,212	$22,848	21,772	$33,067

EXPORTS OF COAL FROM NOVA SCOTIA, THE PRODUCE OF THAT PROVINCE.

TABLE 3.

Years.	Nova Scotia.	
	Tons.	Value.
1873	368,249	$980,534
1874	252,124	647,539
1875	179,626	404,351
1876	126,520	263,543
1877	173,389	352,453
1878	1 4,114	293,795
1879	113,742	203,407
1880	199,552	344,148
1881	193,081	311,721
1882	216,954	390,121
1883	192,795	336,088
1884	222,709	430,330
1885	176,287	349,650
1886	240,459	441,693
Totals..	2,809,601	$5,749,373

EXPORTS OF COAL FROM BRITISH COLUMBIA, THE PRODUCE OF THAT PROVINCE.

TABLE 4.

Years.	Returns of the Dept. of Mines, B.C.	Returns of the Dept. of Customs', Ottawa.
	Tons.	Tons.
1874	56,038	51,001
1875	66,392	65,842
1876	121,284*	116,910
1877	115,381	118,252
1878	164,682	165,734
1879	192,096	186,094
1880	225,849	219,878
1881	189,323	187,791
1882	232,411	179,552
1883	149,567	271,214
1884	6,478	245,478
1885	237,797	250,191
1886	249,205	274,466
Totals.	2,306,503	2,332,403

* This quantity is partly estimated.

EXPORTS OF COAL FROM NEW BRUNSWICK, THE PRODUCE OF CANADA.

TABLE 5.

Years.	New Brunswick.	
	Tons.	Value.
1873	5,599	$61,516
1874	7,606	82,406
1875	4,527	45,949
1876	4,946	35,321
1877	9,669	106,843
1878	7,969	94,904
1879	6,622	85,421
1880	12,350	62,617
1881	14,219	41,458
1882	15,606	15,973
1883	15,641	16,454
1884	1,767	5,579
1885	1,260	3,165
1886	17	162
Totals	107,798	$657,768

Coke. The quantity of coke manufactured in Canada in 1886 has been 35,396 tons, of about $100,000 spot value; it was manufactured in Nova Scotia, and used there in the blast furnaces at Londonderry.

Charcoal. The quantity of charcoal manufactured in the county of Essex, Ontario, during the year 1886, is 901,500 bushels, which, at a value of 6 cents a bushel, represents a total value at the works of $54,090. This charcoal is sold to iron works in the United States, at Detroit or Wyandotte; showing that this fuel could be manufactured in other parts of Ontario to supply Canadian iron works.

The production of charcoal in the county of Essex only has been returned, the addresses of other manufacturers not having been obtained.

COPPER.

There were in 1886, no copper works in operation in Canada, so that all the ores from the different mines have been exported for treatment abroad. Summary.

The total quantity of fine copper contained in the ore exported from the different mines of Canada during the year 1886 is estimated at about 3,505,000 lbs. This quantity of copper represents a value of about $354,000. Besides this copper value, the greater part of these ores was also utilized in acid-making for the sulphur they contain in the state of iron pyrites (see the article on pyrites).

The fine copper contained in the ore exported from Canadian mines in 1885 is estimated to have been about 700,000 lbs. lower than in in 1886.

The total imports of copper in 1886 have reached the value of $259,615, of which $196,846 were pigs, bars, ingots, old and other unmanufactured copper.

Production by districts.

The exports of Canadian copper ore in 1886 were almost entirely from Quebec and Ontario: the quantity of ore exported from Quebec corresponding to a copper content of about 3,338,230 lbs., and the quantity from Ontario to about 164,040 lbs. In Quebec, nearly the whole is from the Albert and Crown mines of Capelton, county of Sherbrooke, from which there have been exported to the United States, 43,906 tons of ore with a copper content of 3,336,810 lbs. as per U. S. Customs returns; this gives about 3·8 as the average percentage of copper in the ore. The whole of the ore exported from Ontario has undoubtedly come from the Sudbury mines, the quantity being 3,307 tons, the declared customs value of which was $16,404; work only began in the Sudbury district late in the year.

IMPORTS OF COPPER.

(From Customs Dept. books.)

Imports and exports.

PROVINCES.	1885.			1886.		
	Pigs, bars, ingots, old, &c.		Manufactured.	Pigs, bars, ingots, old, &c.		Manufactured.
	Pounds.	Value.	Value.	Pounds.	Value.	Value.
Ontario	619,700	$80,868	$31,994	1,159,200	$121,994	$29,162
Quebec	427,400	43,833	8,957	1,146,100	64,349	16,623
Nova Scotia.	59,000	4,968	4,823	64,100	4,823	3,483
N. Brunsw'k	28,100	3,165	3,370	66,200	4,547	4,123
P. E. Island.	2,400	285	97	3,800	480	112
Manitoba ..	100	5	7,198	....	....	4,763
B. Columbia	9,600	1,385	7,453	4,400	653	4,503
Totals..	1,146,300	$134,509	$63,892	2,443,800	$196,846	$62,769

The above table shows the importations of copper in 1885 and 1886, and the following tables 1 and 2 give the exports from Ontario and Quebec; the exports from the other provinces having always been very small, no mention of them has been thought necessary. Table 3 shows that the copper contents and the declared value are too low in the Canadian Customs returns of exports of the Capelton ores at Stanstead, and points to the fact that the exports from Quebec given in table 2 have very probably been really greater throughout.

EXPORTS OF COPPER FROM ONTARIO AND QUEBEC.*

(From Trade and Navigation Returns)

TABLE 1.

Fiscal Years.	Quebec.	Ontario.	Total.
1860...........	$182,112	$283,952	$466,064
1861...........	230,204	210,471	440,675
1862...........	151,184	250,468	401,652
1863...........	301,362	370,570	671,932
1864...........	92,048	478,407	570,455
1865...........	86,155	382,458	468,613
1866...........	25,109	187,940	213,049
1867...........	145,287	197,829	343,116
1868...........	....	....	394,190
1869...........	380,517	135,913	516,430
1870...........	269,757	....	269,757
1871...........	118,798	....	118,798
1872...........	102,210	....	102,210
1873...........	165,897	....	165,897
Total.......	....	....	$5,142,838

* The exports from other Provinces are very small.

EXPORTS OF COPPER FROM ONTARIO AND QUEBEC.*
(From details furnished by Customs' Department.)

TABLE 2.

Calendar Years.	Quebec.		Ontario.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1873...........	1,046,870	$120,532			1,046,870	$120,532
1874...........	932,866	111,727			932,866	111,727
1875...........	1,782,166	241,439			1,782,166	241,439
1876.....	1,882,491	249,971			1,882,491	249,671
1877...........	1,880,090	245,406			1,880,090	245,406
1878...........	355,160	36,499			355,160	36,499
1879...........	408,860	47,817			408,860	47,817
1880...........	1,434,700	192,171			1,434,700	192,971
1881...........	1,244,780	125,753			1,244,780	125,753
1882...........	1,864,170	182,502			1,864,170	182,502
1883...........	1,400,300	148,709			1,400,300	148,709
1884...........	2,714,400	273,422			2,714,400	273,422
1885...........	2,626,000	262,600			2,626,000	262,600
1886...........	2,239,000	232 855	164,040	$16,404	2,403,040	24[illegible]
Totals......	21,811,853	$2,471,903	164,040	$16,404	21,975,893	$2,488,307

* The exports from other Provinces are very small.

COMPARATIVE STATEMENTS OF COPPER CONTENTS OF SAME QUANTITIES OF CANADIAN ORES EXPORTED TO THE UNITED STATES.

TABLE 3.

Fiscal years.	Imported to Vermont as per U.S. Treasury Department Returns.		Exported from Stanstead as per Canadian Customs' Department Returns.		Difference.	
	Pounds of copper	Value. $	Pounds of copper.	Value. $	Pounds of copper.	Value. $
1883	(a.)	120,369	1,192,000	105,144	?	15,225
1884	2,234,642	223,405	1,676,000	171,700	558,642	51,705
1885	2,943,736	294,413	2,452,000	245,200	491,736	49,213
1886	3,318,723	332,033	2,864,000	240,700	454,723	91,333

(a.) Quantity of ore stated—526,694 cwts.

GOLD.

Summary.

The total production of gold in Canada, in 1886, has been 76,879 ozs., valued at $1,330,442. This is an increase over the production of 1885 of 2,541 ozs., and in value an increase of $214,419.

The return of the quantity of alluvial gold washed at Ditton, in Quebec, has not been obtained.

The two great gold producing provinces of the Dominion are British Columbia and Nova Scotia. In British Columbia, the gold has hitherto been derived from the alluvions, but in Nova Scotia, on the contrary, the quartz-veins were worked from the first. In the province of Quebec, gold has also been obtained for a great number of years from the alluvions of the tributaries of the Chaudière River in Beauce County, principally from the Gilbert River.

In several other places in the Eastern Townships of the province of Quebec, rich alluvions were washed, at times, principally at Ditton, in the county of Compton and in the county of Sherbrooke.

A small amount of gold is besides obtained every year from the alluvions of the Saskatchewan River, near Edmonton. In 1885 its value was about $600.

Auriferous quartz-veins have also been worked in several districts in Ontario, and promising mines developed to a small extent, principally in the townships of Marmora, county of Hastings; in the Township of Moss, Algoma; and on the Lake of the Woods. In 1886 none of the mines of these districts have produced any bullion.

Nova Scotia.

The following general statement of the gold production of Nova Scotia in 1886 was kindly sent us by Mr. Gilpin, the Inspector of Mines:

General Statement of Gold Production in Nova Scotia for the year 1886.

Table A.

Districts.	No. of mines.	Days labor.	Mills.	Steam power.	Water power.	Quartz, &c., crushed.	Yield per ton.			Total yield of gold.			Max. yield per ton.		
							oz.	dwt.	grs.	oz.	dwt.	grs.	oz.	dwt.	grs.
Caribou	3	15,394	3	2	1	3,087	0	14	10	2,233	17	10	2	1	0
Darr's Hill	1	27,221	1	0	1	11,628	0	11	4	6,509	0	0	1	6	0
Montagu	1	1,434	2	2	0	77	1	2	18	87	14	0	9	1	0
Oldham	3	13,043	2	1	1	1,026	2	2	20	2,199	3	23	12	1	0
Renfrew	1	3,679	2	0	2	428	0	18	15	283	17	0	1	0	0
Sherbrooke	6	17,669	7	3	4	2,850	0	9	10	1,341	3	9	3	18	12
Stormont	2	3,142	2	2	0	429	1	0	6	435	0	0	1	18	0
Tangier	2	6,399	2	2	0	936	0	17	17	360	19	14	1	7	0
Uniacke	2	3,146	3	3	0	1,263	0	5	2	320	17	8	2	0	0
Waverley	1	2,736	1	1	0	508	0	12	22	329	2	0	1	19	0
Unproclaimed	5	35,017	10	7	3	6,778	1	7	0	9,311	10	22	17	10	0
Totals	27	128,880	35	23	12	29,010	0	16	2	23,362	5	15	17	10	0

Gold was first discovered in Nova Scotia in the Tangier district, in the year 1860; and two years afterwards, when the office of Gold Commissioner was created, work was actively proceeding in eight different districts.

The following tables B. and C., give the production by districts, as well as the yearly output for the whole of Nova Scotia since the beginning of the year 1862. They have been compiled from the annual reports of the Department of Mines of Nova Scotia, which may be referred to for many details concerning the operations of the gold mines in that province since their discovery:—

GOLD PRODUCTION OF THE DIFFERENT DISTRICTS IN NOVA SCOTIA FROM 1862 TO 1886 INCLUSIVE.

TABLE B.

District.	Total quantity of quartz crushed.	Total Yields. Quantity.			Total Yields. Value at $19.50 per oz.	Average yield per ton of 2,000 lbs.
	tons.	oz.	dwt.	grs.		
Caribou	20,958	15,744	10	6	$ 307,018	$14,649
Montague	13,828	28,417	0	10	554,133	40,073
Oldham	31,171	31,459	14	9	613,465	19,680
Renfrew	41,862	29,470	3	23	574,670	13,760
Sherbrooke	158,942	118,283	14	10	2,306,532	14,512
Stormont	15,692	18,362	10	19	358,068	22,819
Tangier	27,418	18,439	19	17	359,578	13,115
Uniacke	31,231	18,108	13	4	353,119	11,305
Waverly	88,953	53,158	18	4	1,036,598	11,653
Wine Harbour	38,944	27,287	16	19	532,112	13,663
Darr's Hill	39,909	18,715	19	19	364,962	9,145
15 Mile Stream	1,088	560	6	23	10,927	10,043
Unproclaimed	42,793	34,406	3	23	670,922	15,678
Totals	552,789	412,415	12	18	$8,042,104	$14,566

YEARLY PRODUCTION OF GOLD IN NOVA SCOTIA SINCE 1862.

TABLE C.

YEAR.	Tons of quartz crushed.	Total yield. Quantity. Oz. Dwt. Grs.	Value @ $19.50.	Average yield per ton of 2,000 lbs.
1862	6,473	7,275 8 0	$141,871	$21.91
1863	17,000	13,971 13 17	272,448	16.02
1864	21,431	20,017 18 13	390,349	18.11
1865	24,421	25,454 3 22	496,357	20.32
1866	32,157	25,204 13 2	491,491	15.28
1867	31,384	27,310 18 11	532,563	16.96
1868	32,259	20,541 6 10	400,555	12.41
1869	35,144	17,868 0 19	348,427	9.91
1870	30,824	19,866 5 5	387,392	12.56
1871	30,787	19,229 7 4	374,972	12.17
1872	17,089	13,094 17 6	255,349	14.81
1873	17,708	11,852 7 18	231,122	13.05
1874	13,844	9,140 13 10	178,244	12.87
1875	14,810	11,211 14 19	218,629	14.89
1876	15,490	11,978 13 18	233,585	15.08
1877	17,369	16,882 6 1	329,205	19.01
1878	17,989	12,577 1 22	245,253	13.63
1879	15,936	13,760 8 21	268.328	16.83
1880	13,997	13,221 13 22	257,823	18.42
1881	16,556	10,756 13 2	209,755	12.66
1882	21,081	14,107 3 20	275,090	13.04
1883	25,954	15,416 9 23	301,207	11.60
1884	25,186	16,079 14 10	313,554	12.44
1885	28,890	22,203 12 20	432,971	14.98
1886	29,010	23,362 5 15	455,564	15.70
Totals	552,789	412,415 12 18	$8,042,104	$14.56

British Columbia.

The statistics for British Columbia were furnished us by the Department of Mines of that province, and are as follows:—

Table 1 is the statement of gold production, as reported by the banks at Victoria.

Table 2 gives the gold returns as estimated by the Gold Commissioners of the different districts.

Table 3 shews the yearly yield of gold since 1858. This table is

taken from the annual reports of the Department of Mines, which may be referred to for detailed information on the operations in the Gold Fields of British Columbia since 1874, when the first report was published.

VALUE OF GOLD EXPORTED BY THE BANKS AT VICTORIA DURING THE YEAR 1886.

TABLE 1.

Bank of British Columbia	$374,398
Bank of British North America	48,519
Garesche, Green & Co	330,127
	$753,043

PRODUCTION OF GOLD AND NUMBER OF MINERS EMPLOYED IN BRITISH COLUMBIA DURING 1886, AS ESTIMATED BY THE GOLD COMMISSIONERS.

TABLE 2.

Districts.	Divisions.	Whites.	Chinese	Yield of gold by divisions.	Total yield by districts.
Cariboo	Barkerville	96	216	$96,000	
	Lightning Creek	44	252	54,800	
	Quesnel Mouth	12	107	45,500	
	Keithley Creek	30	236	61,900	$258,200
		182	811		
Cassiar	Laketon	38	54	41,500	
	McDame Creek	18	27	22,200	
	Skeena	63	17	13,400	77,100
		119	98		
Kootenay	North	128	...	10,000	
	South	49	115	48,500	58,500
Lillooet		177	115		
Omineca		50	400	132,000	132,000
		15	23	17,600	17,600
Yale	Hope, Yale and Lytton	..	250	25,000	
	Kamloops	30	45	22,000	
	Okanagan	14	30	5,000	
	Similkameen	493	295	203,000	255,000
		537	620		$798,400
	Total Whites	1080	....		
	" Chinese	....	2067		
	Total employed	3,147			

ANNUAL PRODUCTION OF GOLD IN BRITISH COLUMBIA SINCE 1858.

TABLE 3.

Year.	Amount actually known to have been exported by banks, &c.	Add one-third more, estimate of gold carried away in private hands.	Total.	Number of miners employed.	Average yearly earnings per man.
1858 (6 months)	$ 390,265	$ 130,088	$ 520,353	3,000	$ 173
1859	1,211,304	403,768	1,615,072	4,000	403
1860	1,671,410	557,133	2,228,543	4,400	506
1861	1,999,589	666,529	2,666,118	4,200	634
1862	3,184,700	1,061,566	4,246,266	4,100	517
1863				4,400	482
1864	2,801,888	933,962	3,735,850	4,400	849
1865	2,618,404	872,801	3,491,205	4,294	813
1866	1,996,580	665,526	2,662,106	2,982	893
1867	1,860,651	620,217	2,480,868	3,044	814
1868	1,779,729	593,243	2,372,972	2,390	992
1869	1,331,234	443,744	1,774,978	2,369	749
1870	1,002,717	334,239	1,336 956	2,348	569
1871	1,349,580	449,860	1,799,440	2,450	734
1872	1,208,229	402,743	1,610,972	2,400	671
1873	979,312	326,437	1 305,749	2,300	567
1874	1,383,464	461,154	1,844,618	2,868	643
1875	1,856,178	618,726	2,474,904	2,024	1,222
1876	1,339,986	446,662	1,786,648	2,282	783
1877	1,206,136	402,045	1,608,182	1,960	820
1878	1,062,670	1·5th 212,534	1,275,204	1,883	677
1879	1,075,049	" 215,009	1,290,058	2,124	607
1880	844,856	" 168,971	1,013,827	1,955	518
1881	872,281	" 174,456	1,046,737	1,898	551
1882	795,071	" 159,014	954,085	1,738	548
1883	661,877	" 132,375	794,252	1,965	404
1884	613,304	" 122,861	736,165	1,858	396
1885	594,782	" 118,956	713,738	2,902	246
1886	753,043	" 150,608	903,651	3,147	287
		Total......	$50,209,517		

Quebec. Chaudière mining division.

The returns made to Mr. Duchesnay, the Mining Inspector of the Chaudière division of the province of Quebec, added to other returns made directly to this office, give 327 ozs., 9 dwts., 22 grs., as the production of gold in that division in 1886.

The following table gives the total production of that division as reported to Mr. Duchesnay since the year 1877, but the real quantity of gold washed each year has been greater than is indicated by these figures, and Mr. Duchesnay estimates that in 1879 he received returns of only about one-half of the actual production, and that in 1880 the actual production was more than $50,000.

Gold was first discovered in that region in 1847; but active operations there date only from 1862. It has been impossible to collect the statistics of the production for each year since that date; it was only learned that in 1867, the returns made to the Mining Inspector gave $31,000, and that in 1868 they were about $25,000.

GOLD PRODUCTION OF THE CHAUDIÈRE DIVISION AS REPORTED TO THE MINING INSPECTOR.

Year.	Total output as reported.					Value @ $17 50 per oz.
	oz.		dwts.		grs.	
1877 (*a*)	688	—	19	—	11	$12,057
1878	1024	—	19	—	5	17,937
1879	1884	—	2	—	7	32,972
1880	1895	—	13	—	4	33,174
1881	3237	—	15	—	17½	56,661
1882	976	—	15	—	0	17,093
1883	1016	—	1	—	21½	17,787
1884	498	—	9	—	3	8,720
1885	120	—	19	—	19	2,120
1886	227	—	9	—	22	3,981

(*a*) Second half of 1877 only.

GRAPHITE.

The total production of graphite in 1886 has been 500 tons, valued at $4,000 at the mine.

EXPORTS OF GRAPHITE.

Year.	Ontario (a.)		Quebec.		New Brunswick.		Total.	
	Cwt.	Value.	Cwt.	Value.	Cwt.	Value.	Cwt.	Value.
1877	429	$1,553	....	$	....	$	429	$1,553
1878	899	3,370	....	....	....	....	899	3,370
1879	275*	1,167	....	....	....	....	275	1,167
1880	....	....	....	....	....	....	....	....
1881	....	....	....	....	....	....	....	....
1882	....	....	....	....	....	....	....	....
1883	....	....	....	....	140	59	140	59
1884	....	....	....	....	....	....	....	....
1885	....	....	6	60	2043	917	2,049	977
1886	....	....	....	....	8142	3586	8,142	3,586
Total ..	1603	$6,090	6	$60	10,325	$4562	11,934	$10,702

(a) The exports from Ontario are probably the produce of the mines of Ottawa county, province of Quebec.

IMPORTS OF BLACK LEAD.

Provinces.	1885.	1886.
Ontario	$9,519	$11,322
Quebec	3,434	4,825
Nova Scotia	2,765	4,333
New Brunswick....	3,622	4,049
Prince Edward Is'd..	440	640
Manitoba	54	94
British Columbia...	540	550
Totals	$20,377	$25,813

GYPSUM.

Summary.

The total production of crude gypsum has not been obtained. Taking the exports from Nova Scotia as representing very nearly the production, and estimating the quantity mined in Ontario to have been 6,000 tons, the total crude gypsum produced in Canada during 1886 may then be estimated at about 162,000 tons, valued in the aggregate, at the point of production, at $178,742; of this, about 7,000 tons were calcined and manufactured, in New Brunswick, into about 51,000 barrels of plaster of Paris, valued on the spot at about $1.00 a barrel; about half of this plaster of Paris was sold in Canada, and the other half exported to the United States. Unknown quantities were ground in Ontario for land plaster or calcined for plaster of Paris.

Compared with 1885, it is estimated that the increase in 1886 in the production of crude gypsum was about 45,000 or 50,000 tons; the Nova Scotia exports alone having increased 36,109 tons.

The total imports were $2,492 worth of crude gypsum, $560 worth of ground gypsum, and $5,602 worth of plaster of Paris.

Production by provinces.

Nova Scotia—The quantity consumed in Nova Scotia is not reported by the Department of Mines, but the quantity exported was kindly furnished us by that bureau as follows:—

Exported From.	Tons.	Value.
Windsor..	96,087	$96,119
Cheverie....	23,272	17,509
St. Anne's (C.B.)..............	4,300	4,000 (a.)
Halifax....	94	492
	123,753	$118,110

(a)—Estimated value.

From the annual reports of the Department of Mines of this province, we gather that the exports of gypsum for the four years 1883 to 1886 were:

	Tons.
1883......................	144,668
1884......................	111,068
1885......................	87,644
1886......................	123,753

These quantities, it will be noticed, do not entirely agree with the export returns of the Customs Department of Ottawa, the table of which is given below.

New Brunswick.

In New Brunswick the production of gypsum in 1886 has been about 32,421 tons, valued on the spot at $48,632, at an average price of $1.50 a ton. It was nearly all produced in Albert County: 1,500 tons only having been estimated as the production from the Victoria County quarries. Besides a large export of crude gypsum to the United States, the Albert Manufacturing Co. also exports a considerable quantity of calcined gypsum, or plaster of Paris, and sup-

plies, moreover, pretty nearly all the Canadian market with this last article. About 4,000 tons of the crude gypsum exported to the United States was white gypsum, suitable for terra alba, and sold in the vicinity of New York city.

Mr. Joseph T. Tomkins, general agent for the Albert Manufacturing Co., Hillsborough, N.B., reports to us as follows:—"After persistent effort and much loss of money in competition with the American tariff, all hope of a successful business in manufacturing plaster of Paris here for the American market was abandoned, and a large factory was added to our works at Newark, New Jersey, the year previous to the advent of the National Policy, which policy alone gave new life to manufacturing plaster, and our Canadian business has increased largely since 1877, the price of our plaster remaining about the same, $1.00 per barrel."

Ontario.

Notwithstanding repeated efforts made by correspondence to obtain returns from all the Ontario producers along the Grand River in the counties of Brant and Haldimand, the return of L. H. Johnson, of the Caledonia Plaster Works, was alone forwarded. (*a.*)

From the annual report of the Bureau of Industries, Ontario, for 1885, and from information kindly sent by Wm. Hamilton Merritt, Esq., of Toronto, the production is estimated to have been about 6,000 tons. Most of it is ground and sold as land plaster, some is calcined for plaster of Paris, and some used as a disinfectant; very little is exported, Ontario not only using nearly all its production, but importing, besides, several thousand tons of crude gypsum and plaster of Paris.

The tables of the imports and exports of gypsum are given below, and shew how much greater the exports are than the imports:—

EXPORTS OF CRUDE GYPSUM.

Years.	Ontario.		Nova Scotia.		New Brunswick.		Total.	
	Tons	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1874	....	....	67,830	$68,164	....	....	67,830	$68,164
1875	....	.. ..	86,065	86,193	5,420	$5,420	91,485	91,613
1876	120	$180	87,720	87,590	4,925	6,616	92,765	94,386
1877	....	....	106,950	93,867	5,030	5,030	111,980	98,897
1878	489	675	88,631	76,695	16,335	16,435	105,455	93,805
1879	579	720	95,623	71,353	8,791	8,791	104,993	80,864
1880	875	1,240	125,685	111,833	10,375	10,987	136,935	124,060
1881	657	1,040	110,303	100,284	10,310	15,025	121,270	116,349
1882	1,249	1,946	133,426	121,070	15,597	24,581	150,272	147,597
1883	462	837	145,448	132,834	20,242	35,557	166,152	169,228
1884	688	1,254	107,653	100,446	21,800	32,751	130,141	134,451
1885	525	787	81,887	77,898	15,140	27,730	97,552	106,415
1886	350	538	118,985	114,116	23,498	40,559	142,833	155,213
Totals	5,994	$9,217	1,356,206	$1,242,343	157,463	$229,482	1,519,663	$1,481,042

(*a.*)—Returns collected at the last moment give a production of 6,400 tons of crude gypsum, valued raw on the spot at $8,000.

Exports of Plaster of Paris.

Provinces.	1884.	1885.	1886.
Ontario	$ 99	$	$
Nova Scotia............	....	294	265
New Brunswick.........	18,569	15,404	24,670
Totals..........	$18,668	$15,698	$24,935

Imports of Crude Gypsum and of Ground Gypsum in 1885 and 1886.

Provinces.	Ground Gypsum.				Crude Gypsum.			
	1885.		1886.		1885.		1886.	
	Pounds.	Value.	Pounds.	Value.	Tons.	Value.	Tons.	Value.
Ontario	26,700	$	26,872	$129	1,954	$2,576	1,557	$2,492
Quebec.	12,212	51	11,210	36	....	....	....	....
Nova Scotia..	....	....	....	....	....	....	....	....
N. Brunswick.	417,800	1,049	150,800	395	....	....	....	....
Prince Ewd. Is	....	....	....	....	....	....	....	....
Manitoba	....	....	....	....	....	....	....	....
Brit. Columbia	325	10	....	....	....	....	....	....
Totals	457,037	$1,173	188,882	$560	1,954	$2,576	1,557	$2,492

Imports of Plaster of Paris.

Provinces.	1885.		1886.	
	Pounds.	Value.	Pounds.	Value.
Ontario	245,340	$1,254	247,906	$1,238
Quebec.......................	13,000	66	33,000	165
Nova Scotia..................	2,127	53	2,056	68
New Brunswick...	57,700	286	56,900	261
Prince Edward Island	....	....	....	....
Manitoba	22,000	90	242,700	1,297
British Columbia.............	264,350	2,567	254,895	2,473
Totals......................	604,517	$4,316	837,457	$5,602

IRON.

Summary.

The total production of iron ore in 1886, taking the Ontario exports as representing the production from that province, has been 69,708 tons, valued at the mines at $126,982.

The quantities used in the blast furnaces at Drummondville have not been obtained.

The total exports were 19,164 tons the declared value of which was $58,410. The total production in 1885, if computed in the same way, gives 69,520 tons, valued at the mines at $115,458; the exports that year were 15,628 tons, valued at $46 307 at the ports of shipment.

No Iron Ore is imported.

Production by province.

The production in 1886 by provinces has been as follows:—

	Tons.		Value at Mines.
Nova Scotia	49,735	@ $1.75	$87,036
Ontario (export returns)	16,032	@ 2.00	32,064
British Columbia	3,941	@ 2.00	7,882
Total	69,708		126,982

Nova Scotia.

The Nova Scotia production is all from the Acadia Iron Mines of the Steel Co. of Canada (Limited), Londonderry, and the Inspector of Mines of this province states in his report that there were also at the Londonderry Mines, in 1886, 947 tons of ankerite mined for a flux.

According to the reports of the Department of Mines, the annual production of iron ore in Nova Scotia from 1876 to 1886 has been :—

1876	15,274	tons of 2,240 lbs.
1877	16,879	"
1878	36,600	"
1879	29,889	"
1880	51,193	"
1881	39,843	"
1882	42,135	"
1883	52,410	"
1884	54,885	"
1885	48,129	"
1886	44,388	"

Ontario.

The exports of iron ore from Ontario in 1886 can be divided into about 11,000 tons from the Hastings district, and 5,000 tons from the Kingston district.

British Columbia.

In British Columbia, the mine on Texada Island was the only one in operation in 1886; the ore was shipped to Irondale, Washington Territory, and smelted there with a mixture of bog-ore, by the Puget Sound Iron Co.

In the two following tables, and in the preceding table of the Nova Scotia production, very nearly all the iron ore extracted from the iron mines of Canada during the years mentioned is shewn, and these tables indicate to how small an extent the iron mines of Canada have been developed. **Exports.**

EXPORTS OF IRON ORE FROM THE PROVINCES OF ONTARIO AND QUEBEC FROM 1859 TO 1867 INCLUSIVE, AND FROM THE DOMINION FROM 1868 TO 1873 INCLUSIVE.

Fiscal Years.	Tons.	Value.	
1859	9,217	$ 25,965	
1860	9,744	34,165	All to U. S.
1861	932	2,430	" "
1862	3,141	10,197	" "
1863	5,420	18,124	
1864	6,193	24,573	
1865	5,946	27,272	
1866	3,357	22,727	
1867	4,194	12,798	
1868	(a) 25,312	54,723	
1869	27,848	60,298	
1870	15,232	34,927	
1871	26,825	58,068	
1872	26,175	64,904	
1873	(b) 47,200	112,366	
Totals ..	216,736	$563,537	

(a) The Blairton Mine was working this year.
(b) Mines of Ottawa County working this year.

EXPORTS OF IRON ORE.

Years	Ontario.		Quebec.		Nova Scotia.		N. Brunsw'k		B. Columbia.		Total.	
	Tons.	Value.	Tons	Value.	Tons	Value.	Tons	Value.	Tons.	Value.	Tons.	Value.
1878.	55,990	$124,173	400	$4,400	57	$2,010	....	....	....	....	56,447	$ 130,583
1874.	37,101	83,759	1	10	12	270	274	$2,378	....	....	37,388	86,417
1875.	13,331	28,467	2	18	5	80	....	....	....	....	13,338	28,565
1876.	9,452	18,345	....	....	2	50	1	2	....	....	9,455	18,397
1877.	3,782	10,514	....	....	3	14	....	....	....	....	3,785	10,528
1878.	4,295	8,643	....	....	....	3	....	....	20	$ 200	4,315	8,846
1879.	9,465	20,963	....	1	2	10	....	....	....	....	9,467	20,974
1880.	48,377	123,867	....	....	....	....	5	18	300	300	48,682	124,180
1881.	40,894	121,232	128	154	5	86	....	....	1,200	1,200	42,227	122,622
1882.	54,752	171,219	....	....	....	....	206	3,090	1,690	3,380	56,648	177,689
1883.	25,205	68,270	18	256	25	625	103	1,648	240	480	25,591	71,279
1884.	49,275	114,517	....	....	....	....	1	4	3,535	7,887	52,811	122,406
1885.	15,426	45,433	....	....	....	....	12	449	190	425	15,628	46,307
1886.	16,032	51,175	2	10	....	....	....	....	3,130	7,225	19,164	58,410
Tot'ls	383,377	$990,577	551	$4,849	111	$3,098	602	$7,584	10,305	$21,097	394,946	$1,027,205

Iron and Steel Industry. A commencement was made in the collection of statistics of the consumption and production of the branches of the iron and steel industries which produce iron and steel from raw materials or through secondary operations, or in other words, an attempt has been made to collect statistics of the products of the blast furnaces, rolling mills steel works and forges.

But as full replies to the enquiries made have not been obtained, and as our list of all the iron works was incomplete, the results so far attained, if summarized, would not give a fair statistical account of the iron and steel industry in the Dominion. We shall therefore, in this report give only the exports and imports of iron and steel for the calendar years 1885 and 1886 which have been compiled from the books of the Customs Department, hoping to be able next year to add to this the statistics of the total production and of the total consumption in the country.

Exports. Table 1 gives the exports of scrap iron and of the iron and steel goods manufactured in Canada; a great increase in the exports of scrap iron in 1886 will be noticed due to a scarcity of ore in the United States, and to the fact that the American manufacturer, being thoroughly protected, could afford to outbid our own manufacturer.

In table 3, the articles mentioned in the note (*a.*) were not included, so as to give a fairer idea of the market now available in the Dominion for the raw material and which might be supplied by iron and steel manufactured here. The tables 4, 5, 6, 7 and 8 shew the details of the imports of the different articles included under the headings: iron, steel, castings and orgings, railroad iron and steel, and hardware and manufactures, in table 3; the articles left out can be seen by comparing these lists of articles with the list of imported goods of the Trade and Navigation returns. Imports.

EXPORTS OF IRON AND STEEL GOODS THE PRODUCE OF CANADA.

TABLE 1.

ARTICLES. (*a*)	1884	1885	1886
Scrap Iron......................	$ 11,378	$ 1,192	$ 77,546
Castings........................	8,995	7,848	13,599
Stoves..........................	640	1,864	4,701
All other iron, and Hardware....	140,170	84,807	91,298
Steel and manufactures of.......	25,671	19,447	40,883
Totals..................	$186,854	$115,158	$228,027

(*a*) No exports of Pig Iron.

IMPORTS OF PIG IRON BY PROVINCES.

TABLE 2.

PROVINCES.	Pig Iron. (Charcoal.)				Pig Iron. (All other.)			
	1885.		1886.		1885.		1886.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Ontario	939	$16,921	4,072	$76,795	16,210	$231,509	16,418	$219,495
Quebec...............	108	2,489	463	10,426	21,203	241,508	22,014	222,756
Nova Scotia..........	65	1,280	33	780	1,467	17,764	827	13,147
New Brunswick......	....	....	....	....	2,684	40,513	2,824	51,352
Prince Edward Island	....	....	....	....	67	767	78	814
British Columbia.....	....	....	....	....	1,021	13,662	631	8,819
Totals............	1,107	$20,690	568	$88,001	42,652	$545,723	42,792	$516,383

SUMMARY TABLE OF THE IMPORTS OF PIG IRON, IRON AND STEEL (a).

TABLE 3.

ARTICLES.	1885.	1886.
Pig Iron, Charcoal........	$ 20,690	$ 88,001
" " all other........	545,723	516,383
Iron....................	2,700,243	3,024,410
Steel....................	636,613	850,816
Castings and Forgings.....	468,137	562,709
Railroad Iron and Steel....	2,468,419	2,289,373
Hardware and m'frs	411,199	396,081
Totals........	$7,251,024	$7,727,773

(a.) Not including cutlery, edge-tools, machinery and engines, and other hardware and manufactures, in the price of which the principal item is not the weight of the metal.

IMPORTS OF IRON.

TABLE 4.

ARTICLES.		1885.		1886.	
		Quantity.	Value.	Quantity.	Value.
			$		$
Band and hoop iron, No. 17 guage, or thinner,	cwt.	28,387	55,689	32,085	52,412
" " " 17 " thicker	"	36,718	48,774	47,605	57,463
Bars, rolled or hammered, including flats, rounds and squares..	"	625,604	801,512	633,235	675,308
Boiler-plate	"	83,402	153,221	120,681	176,929
Canada plates	"	116,804	222,737	106,690	171,330
Iron, N.E.S..........................	"	339	648	1,552	1,917
" other in slabs, blooms, loops, &c.....	"	252,123	232,919	360,352	295,474
Nail and spike rods.....................	"	3,754	10,507	20,165	36,965
Rolled beams, channels, and angle and T iron, steel, or iron and steel, N.E.S ..	"	52,821	86,918	119,238	167,509
Rolled round wire rods, in coils, under ½ in. diam.	"	999	1,708	1,074	1,724
Sheet iron, smoothed or polished, coated or galvanised, and common or black, 17 guage and thinner	"	87,590	262,736	113,818	320,470
Ditto, ditto, thicker than 17 guage.......	"	49,089	74,558	34,112	45,692
Tubing, wrought iron, plain, not threaded, coupled or otherwise mfd., and over 2 in. diam....	feet.	365,965	40,032	473,587	49,290
Tubing, wrought iron, threaded, coupled, or otherwise mfd., and over 2 in. diam.	"	173,181	34,339	389,321	68,910
Tubing, wrought iron, plain, 2 in. diam. or under, threaded and coupled, or not....	"	3,834,639	154,913	5,285,119	276,706
Lap-welded boiler tubing, not threaded, coupled or otherwise mfd., ½ in. diam. and over	"	453,951	42,072	735,191	55,025
Wire, iron and steel, 15 guage and coarser, and N.E.S	cwt.	101,297	244,061	136,234	333,013
Hoop iron, not exceeding ⅜ in. in width, and being 25 guage or thinner, for mfr. of tubular rivets	"	89	1,132	48	623
(a) Iron and steel, old and scrap.....	"	163,909	124,765	247,884	171,951
Iron or steel beams, sheets, plates, angles and knees, for iron or composite ships or vessels	"	788	1,051	19,468	17,242
Wire of spring steel, coppered, for mfr. of mattrasses, 9 guage and smaller	lbs.	470,908	21,903	780,869	32,347
Wire of iron or steel, galvanised or tinned or not, 15 guage or smaller	"	1,822,165	84,048	1,698,500	84,171
Totals...........................			$2,700,243		$3,024,410

(a.)—The Iron and Steel could not be separated.

IMPORTS OF STEEL.

TABLE 5.

ARTICLES.	1885.		1886.	
	Quantity.	Value.	Quantity.	Value.
Locomotive tires of steel or Bessemer.......cwt.	5,979	$ 27,039	14,132	$ 48,279
Steel, ingots and bars (if from shears and rolls only) .... "	114,076	290,136	175,916	367,260
Steel, sheets, under 3-16 in. thick, whole or cut to shape .... "	11,446	29,359	18,014	33,841
Steel, sheets, thicker than 3-16 in. thick, and N.E.S........ "	15,041	39,324	40,006	76,842
Steel, coils, rolled round wire rods, N.E.S... "	....	....	661	1,095
Steel, wire rods, rolled round, under ½ in. diam., imported by wire mfrs. for use in their factories........ "	13,813	23,301	48,650	65,607
Axes	....	8,132	....	8,148
Saws........	....	68,639	....	64,250
All manufactures of steel, and iron and steel, N.E.S........	....	91,886	....	90,897
Steel for manufacture of skates........cwt.	1,017	5,757	1,197	4,591
" " saws and straw cutters........ "	4,881	51,935	10,264	71,773
Steel, crucible sheet, 11 to 16 guage, for mower and reaper knives........ "	75	280	687	2,739
Steel, No. 20 guage and thinner, and not thinner than 30 guage, for manufacture of corset steels, shanks, &c........ "	262	983	976	4,597
Steel in sheets, not less than 11 or over 18 wire guage, for mfr. of shovels and spades .... "	1,238	4,842	2,986	10,897
Totals........	....	$686,613	....	$850,816

IMPORTS OF CASTINGS AND FORGINGS.

TABLE 6.

ARTICLES.	1885.		1886.	
	Quantity.	Value.	Quantity.	Value.
Castings, every description, N.E.S., and forgings.	....	$ 268,301	....	$ 282,766
Cast-iron gas, water and soil pipes........	....	58,080	....	155,209
Chains, iron or steel, over 9-16 in. diam......cwt.	23,955	49,441	22,439	45,498
Chain cables, all other........ "	19,974	57,790	17,151	48,268
Malleable iron castings........	....	19,752	....	19,822
Anchors ....cwt.	3,251	14,058	3,797	10,146
Iron masts for ships........ "	67	715	....	1,000
Totals........	....	$468,137	....	$562,709

Imports of Railroad Iron and Steel.

Table 7.

Articles.	1885.		1886.	
	Quantity.	Value.	Quantity.	Value.
		$		$
Car wheels ....cwt.	5,065	15,150	12,703	51,5[illegible]
Railway bars, or iron rails for railways or tramways .... "	13,764	26,328	20,908	26,[illegible]31
Railway fish-plates, frogs, frog-points, chairs and finger bars .... "	13,917	23,158	117,600	116,000
Steel railway bars or rails, not including tram or street rails .... "	775,403	1,047,900	2,172,023	1,512,9[illegible]5
Materials for original construction, C. P. Ry. :—				
Bolts and nuts ....cwt.	8,[illegible]39	5,024	....	....
Fish-plates .... "	46,941	50,533	....	....
Spikes .... "	7,790	21,827	....	....
Steel rails .... "	857,058	1,097,215	516,[illegible]83	554,0[illegible]2
Material for original construction Esquimalt and Nanaimo Railway:—				
Bolts and nuts ....cwt.	663	1,980	197	4[illegible]3
Fish-plates .... "	56,804	41,608	778	1,4[illegible]
Spikes .... "	1,160	3,743	940	2,516
Steel rails .... "	57,510	133,958	13,440	24,000
Totals		$2,468,419		$2,289,373

Imports of Hardware and Manufactures.

Table 8.

Articles.	1885.		1886.	
	Quantity.	Value.	Quantity.	Value.
		$		$
Anvils ....cwt.	1,275	5,892	929	5,233
Axles of iron and steel .... "	228	549	7,866	11,779
Bolts and nuts, stove, and all bolts and rivets ¼ in. diam. and less .... lbs.	....	....	20,747	2,256
Bolts, washers and rivets	...	76,177	....	34,343
Horse-shoes and horse-shoe nails	....	4,089	....	3,566
Iron bridges and structural ironwork ....cwt.	4,466	20,508	30,750	49,8[illegible]
Nails, Hungarian and clout .... lbs.	61,903	2,759	8[illegible],062	4,073
" iron wire "Pointes de Paris" .... "	127,681	5,219	262,572	10,043
" and spikes, wrought and pressed, incl. railway spikes	423,389	14,060	670,538	17,612
Nails and spikes, cut .... "	411,968	13,436	182,681	7,176
Nuts, N.E.S. .... "	199,702	9,547	110,379	4,950
Screws, iron and steel, "wood screws" ....gross.	427,992	30,268	187,524	24,10[illegible]
Stoves ....No.	3,312	26,740	1,745	21,124
Tacks, brads and sprigs .... lbs.				
Wire fencing, barbed, of iron and steel (from 31st March, 1886) .... "	...	5,384	....	8,406
Wire fencing, Buckthorn, &c., (from 31st March, 1886) .... "	....	....	63,815	2,545
Wire, covered with cotton, silk, &c. (from 29th May, 1886) .... "	....	....	6,682	29[illegible]
Wire rope, strand or chain, made of iron or	....	..	67,809	19,462
steel wire .... cwt.	3,811	31,224	1,965	16,564
Wirework, other .... "	....	93,280	....	104,470
Manufactures of iron, All other, N.O.P.F.	....	41,277	....	25,896
Wire rigging for ships or vessels .... cwt.	6,079	26,841	6,067	17,775
Nails, spikes and sheathing nails composition, lbs.	38,944	4,449	36,021	4,695
Totals	....	$411,199	....	$396,081

LITHOGRAPHIC STONE.

Beds of excellent lithographic stone have long been known to exist in Ontario, principally in the counties of Hastings, Peterboro and Bruce, towards the base of the Birds-eye and Black River formation. The different quarries, so far as ascertained, have only produced specimens in 1886.

IMPORTS OF LITHOGRAPHIC STONE.

Provinces.	1885.	1886.
Ontario	$1,033	$4,037
Quebec	926	1,715
New Brunswick	2	8
British Columbia	27	2
Totals	$1,988	$5,762

MANGANESE.

Summary.

The production of manganese ore in 1886, has been 1,789 tons, valued at the mines at $41,499. It is supposed that a small quantity from New Brunswick has not been returned, and should be added to that total.

In 1885, the production of manganese ore in Nova Scotia is stated in the report of the Inspector of Mines of that province, to have been 353½ tons, and the exports from New Brunswick that year were 1,607 tons, valued at the ports of shipment at $29,595.

Nova Scotia and New Brunswick are the only two provinces of the Dominion where manganese mines have been in active operation.

Nova Scotia.

In 1886 274½ tons of manganese ore was mined at Teny Cape, Cheverie, East Onslow, Stewiacke and Walton in Nova Scotia; the reported value of which at the mines was $19,248.

Table A. gives the production in that province since 1877 as per the Department of Mines Annual Reports.

PRODUCTION OF MANGANESE ORE IN NOVA SCOTIA.

TABLE A.

Years.	Tons.	Value.
1877	97	....
1878	127	$5,505
1879	145	7,170
1880	223	7,931
1881	231	....
1882	205	....
1883	150	12,462
1884	302½	....
1885	353½	....
1886	(a) 427	....
Total..	2,261	

(a.) 250 tons from Cornwallis included in this quantity would more correctly be classed as an ochre.

New Brunswick.

In New Brunswick the production in 1886 was 1,515 tons, valued at the mines at $22,051.

Exports and Imports.

Tables 1 and 2 give the exports since 1868, and Table 3 the imports of oxide of manganese in 1885 and 1886.

EXPORTS OF MANGANESE ORES.

TABLE 1.

FISCAL YEARS.	Nova Scotia.		New Brunswick.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1868.............	156	$4,700	861	$19,019	1,017	$23,719
1869.............	156	4,695	332	6,174	488	10,869
1870.............	1,256	4,102	146	3,580	1,402	7,682
1871.............	102	1,608	954	8,180	1,056	9,788
1872.............	131	4,005	1,075	24,495	1,206	28,500
1873.............	....	....	838	17,171	838	17,171
Totals	1,801	$19,110	4,206	$78,619	6007	$97,729

EXPORTS OF MANGANESE ORES.

TABLE 2.

YEARS.	NOVA SCOTIA.		NEW BRUNSWICK.		TOTAL.	
	Tons.	Value	Tons.	Value.	Tons.	Value.
1873	....	$......	1,031	$20,192	1,031	$20,192
1874	6	12	776	16,961	782	16,973
1875	9	200	194	5,314	203	5,514
1876	21	723	391	7.316	412	8,039
1877 (*b*)	106	3,699	785	12,210	891	15,909
1878	106	4,889	520	5,971	626	10,860
1879	154	7,420	1,732	20,016	1,886	27,436
1880	79	3,090	2,100	31,707	2,179	34,797
1881	200	18,022	1,504	22,532	1,704	40,554
1882	123	11,520	771	14,227	894	25,747
1883	313	8,635	1,013	16,708	1,326	25,343
1884	134	11,054	469	9,035	603	20,089
1885	77	5,054	1,607	29,595	1,684	34,649
1886	441 (*a*.)	30,854	1,377	27,484	1,818 (*a*.)	58,338
Totals..	1,769	$105,172	14,270	$239,268	16,039	$344,440

(*a*.) 250 tons from Cornwallis included in this quantity more properly come under the heading mineral pigment.

(*b*.) 2 tons, valued at $6, were exported from Quebec that year.

IMPORTS OF OXIDE OF MANGANESE.

TABLE 3.

Provinces.	1885.		1886.	
	Pounds.	Value.	Pounds.	Value.
Ontario	20,158	$ 648	16,464	$ 824
Quebec	22,637	1,123	29,413	1,530
Nova Scotia	1,087	76	1,075	75
New Brunswick	950	27	....	....
Manitoba	....	....	609	26
Totals	44,832	$1,874	47,561	$2,455

MICA.

The quantity of cut mica, of domestic production, returned to this office as having been sold in 1886 was 20,361 lbs., valued on the market at $29,008, the average price therefore being $1.42 a pound. This represents the production of four different mines, three in Ontario and one in Quebec, and is believed to be all that was produced in Canada in 1886. The low average price of $1.42, is due to the fact that the largest producer is not selling a first class quality; but the average price of that from the other mines is between $2.50 and $3.00. This shows that much of our mica is of very fine quality as the average price in 1885 of all the mica sold in the U. S., was computed at $1.75 a pound. A very appropriate remark made in the report of the Mineral Resources of the United States (1885) may nevertheless be quoted: "The fact that fine, large sheets of mica have a value of several dollars per pound, reaching in exceptional cases as much as $10 per pound for special purposes, has led to popular misapprehension in regard to the average value of this mineral;" and the average price in 1885 is given, as above stated, at $1.75 a pound. It must also not be forgotten, in considering the value of a mica mine, that great waste is always to be expected on account of the numerous naturally bad portions in the deposits, causing inevitable loss in mining and cutting.

MINERAL PIGMENTS.

Baryte.

The total production of baryte in 1886 was 3,864 tons, valued at the mines at $19,270. In 1885, the production was only 300 tons from the Stewiacke mine, Nova Scotia. The increase in 1886 is due to the working of a large vein on McKellar's Island, Lake Superior.

IMPORTS OF UNMANUFACTURED BARYTE.

PROVINCES.	1885.		1886.	
	Cwt.	Value.	Cwt.	Value.
Ontario	..	$ 2	45	$291
Quebec	..	...	127	80
Nova Scotia	6½	16	238	54
New Brunswick	..	...	6	47
Totals	6½	$18	416	$472

Litharge.

IMPORTS OF LITHARGE.

PROVINCES.	1885.		1886.	
	Cwt.	Value.	Cwt.	Value.
Ontario	1,540	$ 5,270	3,843	$13,001
Quebec	2,259	6,575	1,891	6,289
Nova Scotia	20	100	2	8
New Brunswick	2	11	13	85
Manitoba	11	40	10	41
British Columbia	12	72	6	35
Totals	3,844	$12,068	5,765	$79,459

Terra Alba.

Terra alba.—About 4,000 tons have been exported in 1886 from the gypsum quarries of Hillsboro, New Brunswick; it was worth, laid down in New York, from $5 to $7 per ton. When ground, it produces a quality of terra alba No. 1, worth from $14 to $15 per ton. The quantity shipped from Windsor, Nova Scotia, is not known.

So far as returned to this office, 400 barrels of whiting were produced in Ontario, valued at about $600. Whiting.

IMPORTS OF WHITING.

Provinces.	1885.		1886.	
	Cwt.	Value.	Cwt.	Value.
Ontario	6,532	$ 2,467	10,272	$ 3,577
Quebec	53,352	21,097	24,839	8,698
Nova Scotia	2 488	1,120	8,654	1,823
New Brunswick	2,949	1,206	2,773	1,166
Prince Edward Island	368	174	109	61
British Columbia	295	236	739	857
Totals	65,984	$26,300	47,386	$16,182

IMPORTS OF CHALK.

Provinces.	1885	1886
Ontario	$4,882	$3,053
Quebec	1,322	1,657
Nova Scotia	230	167
New Brunswick	66	191
Prince Edward Island	23	30
Manitoba	71	208
British Columbia	13	28
Totals	$6,607	$5,334

MISCELLANEOUS METALS.

Lead. It is believed that there was no production or smelting of lead ore in Canada during 1886. Some preparatory work was done in opening up galena veins on Lake Temiscaming, Quebec, and in the Selkirks, British Columbia.

The exports of lead ore since 1873 are given in the following table 1, which shows how small they have always been.

Table 2 shows the imports of lead.

Zinc. Table 3 gives the imports of zinc. The Zenith Zinc Mine, on the north shore of Lake Superior, was not worked in 1886.

Tin. Tables 4 and 5 give the imports of tin. Tin has not yet been discovered in Canada.

Mercury. Cinnabar was discovered in 1886 in the Rocky Mountains, near Golden City. It has been found in several other places in British Columbia, but not yet in workable quantity. The imports of mercury are given in table 6.

EXPORTS OF LEAD ORE FROM CANADA.

TABLE 1.

Years.	Nova Scotia.		New Brunswick.		Quebec.		British Columbia.		Prince Ed. Island.		Total.	
	Tons	Value.	Tons	Value.	Tons	Value.	Tons	Value.	Tons	Value.	Tons	Value.
1873	3	$263	53	$1,730	....	$	....	$	....	$	56	$1,993
1874	....	......	4	77	....	......	....	......	3	50	7	127
1875	....	......	1	10	177	7,500	....	......	....	......	178	7,51[illegible]
1876		50	2	16	....	......	....	......	....	......	9	66
1877	9	720	....	......	....	......	....	......	....	......	9	720
1878	....	......	....	......	....	......	....	......	....	......	....	......
1879	....	......	....	......	2	230	....	......	....	......	2	230
1880	....	......	....	......	....	......	....	......	....	......	....	......
1881	....	......	....	......	....	......	....	......	....	......	....	......
1882	....	......	2	32	....	......	....	......	....	......	2	32
1883	....	......	....	......	....	......	8	5	....	......	8	5
1884(a)	....	......	....	......	4	36	....	......	....	......	4	36
Totals..	19	$1,033	62	$1,865	183	$7,766	8	$5	3	$50	275	$10,71[illegible]

(a) No exports in 1885 and 1886.

IMPORTS OF LEAD.

TABLE 2.

Articles.	1885.		1886.	
	Cwt.	Value.	Cwt.	Value.
Lead, Old, Scrap and Pig......	37,320	$91,289	68,794	$142,667
" Bars, Blocks and Sheets..	8,651	22,578	10,488	32,450
" Pipe	....	....	613	2,016
" Shot..................	3,627	11,155	2,907	9,661
" Manufactures of.........	....	25,911	....	9,884
Totals.............	....	$150,933	....	$196,678

IMPORTS OF ZINC IN BLOCKS, PIGS AND SHEETS.

TABLE 3.

Provinces.	1885.		188	
	Cwt.	Value.	Cwt.	Value.
Ontario	7,879	$23,331	5,307	$19,667
Quebec	13,001	42,520	15,457	56,905
Nova Scotia.............	1,466	9,259	1,456	5,973
New Brunswick..........	1,741	6,662	1,457	7,387
Manitoba	......	......	50	199
British Columbia	162	924	209	785
Prince Edward Island....	168	653	102	371
Totals..............	24,417	$83,349	24,038	$91,287

IMPORTS OF TIN.

TABLE 4.

Provinces.	1885.				1886.			
	Blocks, Pigs and Bars.		Tin-foil.		Blocks, Pigs and Bars.		Tin-foil.	
	Cwt.	Value.	Pounds.	Value.	Cwts.	Value.	Pounds.	Value.
Ontario	2,179	$33,622	27,023	$4,244	4,017	$73,661	30,929	$5,480
Quebec	3,125	54,406	57,066	10,383	7,822	104,717	57,602	11,226
Nova Scotia	1,581	25,288	140	25	2,423	39,937	1,083	255
New Brunswick	667	18,292	142	78	587	11,333	184	45
Manitoba	....	....	318	141	42	939	655	230
British Columbia	402	8,251	232	88	1,639	36,301	50	14
Prince Edward Island	482	9,058	....	....	451	10,047	....	...
Total	8,436	$148,917	84,951	$14,959	16,981	$276,935	90,453	$17,250
Total Tin-foil—cwts	850	14,959	....	...	905	17,250	....	...
Total Tin	9,286	$163,876	....	....	17,886	$294,185	....	....

IMPORTS OF TIN PLATES AND SHEETS.

TABLE 5.

Provinces.	1885.		1886.	
	Cwt.	Value.	Cwt.	Value.
Ontario	50,192	$193,888	67,200	$248,899
Quebec	65,979	261,189	75,302	251.240
Nova Scotia	31,410	101,695	29,346	96,101
New Brunswick	16,039	59,830	7,769	29,316
Manitoba	1,487	4,848	1,415	4,380
British Columbia	8,503	36,029	35,933	145,413
Prince Edward Island	9,790	30,084	9,106	27,006
Totals	183,400	$687,563	226,071	$802,355

IMPORTS OF MERCURY.

TABLE 6.

PROVINCES.	1885.		1886.	
	Pounds.	Value.	Pounds.	Value.
Ontario	7,148	$ 3,041	8,742	$5,020
Quebec	1,793	795	1,422	684
Nova Scotia	2,608	1,094	1,648	1,052
New Brunswick..........	......	3	20	11
Manitoba	2	3	80	44
British Columbia	3,064	1,273	4,210	1,981
Totals..............	14,610	$ 6,209	16,122	$8,792

PETROLEUM.

Summary.

The total quantity of crude petroleum produced in Canada in 1886 has not been obtained, as it has been impossible to get the statistics of that which has been sold and consumed as such; but, the great bulk of the product of the wells was refined, and the statistics of these quantities of refined oil, as well as their reduction into crude equivalent, are as below.

The quantity of Canadian refined oil (refined petroleum and naptha) which has been inspected during the year 1886, is 6,469,667 imperial gallons. This, at the yield of 38 gallons refined oil from 100 crude, corresponds to 17,025,439 gallons of crude petroleum, or 486,441 barrels of 35 gallons. The spot value of this quantity of crude oil may be stated at $437,797, if 90c. is taken as the average market price of a barrel.

Exports.

241,716 gallons only were exported in 1886, probably all crude oil.

Imports.

The imports in 1886, on the contrary, are much larger, they amounted to:—1,584,422 gallons of refined; 2,595,429 gallons of crude; and, 468,095 gallons of other products of petroleum (heavy oils).

Tables of inspection returns.

In the following tables, A., B. and C., will be found condensed all the available official returns, giving some statistics of the petroleum production since 1868; but, before July 1880, it is impossible to tell what portion of the quantity of crude manufactured in Canada was domestic oil, as there was no discrimination in favor of Canadian petroleum until the Inspection Act was amended by 43 Vic., Chap. 21, on May 7th, 1880. Therefore, only in table C. is the production of oil from the Canadian wells given, but not the whole of that production, as the crude oil, utilized as such, is not included in the figures in that table.

RETURNS OF QUANTITIES OF CRUDE OIL USED BY REFINERIES IN CANADA, AND OF REFINED PETROLEUM AND TAR PRODUCED.

TABLE A.

Fiscal Years.	Crude Oil.	Refined Oils.	Tar and Residuum.	Measure.
1868 (*a*)	251,882	237,765	1,216	Wine Gallons.
1869	4,722,872	2,772,224	207,658	"
1870	16,792,127	10,736,636	1,117,617	"
1871	17,916,350	11,689,761	1,469,590	"
1872	19,934,047	12,323,991	1,140,107	"
1873	25,244,438	14,602,087	1,613,555	"
1874	9,251,070	6,752,282	828,858	"
1875	8,643,409	4,811,596	286,257	"
1876	9,417,901	4,838,215	262,733	Imperial Gallons.
1877	15,964,647	7,913,754	99,680	"

(*a*) Part of the year only.

PETROLEUM INSPECTED AND CORRESPONDING QUANTITIES OF CRUDE OIL.

TABLE B.

Fiscal Years.	Refined Oils Inspected.	Crude Equivalent Calculated.	Ratio of Refined to Crude.
	Imp. gallons.	Imp. gallons.	
1878	4,493,760	8,987,520	50 : 100
1879	5,559,005	11,118,010	50 : 100
1880	5,728,636	11,457,272	50 : 100

CANADIAN PETROLEUM AND NAPHTA INSPECTED AND CORRESPONDING QUANTITIES OF CRUDE OIL.

TABLE C.

Calendar Years.	Refined Oils Inspected.	Crude Equivalent Calculated.	Ratio of Refined to Crude.
	Imp. gallons.	Imp. gallons.	
1880 (*a*)	3,233,854	6,467,708	50 : 100
1881	5,380,081	10,760,162	50 : 100
1882	5,111,893	11,359,762	45 : 100
1883	6,204,544	13,787,875	45 : 100
1884	6,730,068	16,825,170	40 : 100
1885	5,853,290	14,633,225	40 : 100
1886	6,469,667	17,025,439	38 : 100

(*a*) Second half of year only.

The imports of petroleum are given in the three following tables for the calendar years 1885 and 1866; the returns of refined oils have been obtained from the Inland Revenue Department by calendar years since 1881:— Imports.

PETROLEUM AND NAPTHA IMPORTED.

TABLE 1.

Years.	Imperial Gallons.
1881	1,111,338
1882	1,226,918
1883	1,110,580
1884	1,231,984
1885	1,211,152
1886	1,584,422

CRUDE OIL IMPORTED.

TABLE 2.

Years.	Imperial Gallons.
1885	2,599,064
1886	2,595,429

IMPORTS OF CRUDE AND REFINED PETROLEUM.

TABLE 3.

PROVINCES.	1885.		1886.	
	Gallons.	Value.	Gallons.	Value.
Ontario	1,398,242	$151,884	1,563,864	$179,756
Quebec	612,149	62,461	759,312	69,526
New Brunswick	766,052	64,214	804,911	82,636
Nova Scotia	628,291	64,657	699,480	66,690
Prince Edward Island	213,824	12,756	170,736	18,818
Manitoba	18,475	1,821	7,627	871
British Columbia	173,083	54,344	173,921	50,934
Totals	3,810,116	$412,137	4,179,851	$469,231

The two following tables give the exports of Canadian petroleum (refined and crude) since the beginning of operations in 1861.

EXPORTS OF CANADIAN PETROLEUM.

Fiscal Years.	Wine Gallons.	Value.
1861	49,880	$ 8,155
1862	1,744,140	236,792
1863	445,090	86,319
1864	265,765	55,663
1865	47,311	21,155
1866	6,515	2,878
1867	31,729	7,782
1868	46,282	9,341
1869	690,553	127,319
1870	4,748,557	966,461
1871	5,753,678	1,052,879
1872	7,897,054	1,341,099
1873	9,355,325	1,819,183
Totals.	31,081,879	$5,735,026

EXPORTS OF CANADIAN PETROLEUM.

Years	Ontario.		Quebec.		Nova Scotia.		New Brunswick.		Total.	
	Gallons.	Value.	Gallons.	Value.	Galls.	Value.	Galls.	Value.	Gallons.	Value.
		$		$		$		$		$
(b) 1873.	5,781,879	1,261,424	84,442	24,732	3,758	1,420	....	...	5,869,579	1,287,576
1874.	22,955	1,254	4,734	857	1,257	398	....	....	28,946	2,509
1875.	563	66	11,051	2,081	202	67	....	....	11,836	2,214
1876.	2,065,907	469,708	467,068	113,558	797	284	....	....	2,533,772	583,550
1877.	1,401,148	317,715	27,680	4,381	3,110	917	....	....	1,431,883	323,013
1878.	602,460	84,336	2,764	457	3,947	778	....	....	609,171	85,571
1879.	232,688	16,584	369	62	2,114	386	....	....	235,171	17,032
1880.	1,601	446	470	101	1,014	204	....	....	3,085	751
1881.	....	....	....	....	501	99	....	....	501	99
1882.	....	....	479	102	640	184	....	....	1,119	286
1883.	11,562	358	659	109	1,062	243	....	....	13,283	710
1884.	1,096,440	29,771	886	137	722	254	42	6	1,098,090	30,168
1885.	335,945	(a) 9,980	578	96	1,449	486	....	....	337,967	10,562
1886.	238,628	9,282	2,571	470	1 7	103	....	....	241,716	9,855
Total.	11,791,291	$2,220,924	603,696	$147,143	21,090	$5,823	42	$6	12,416,119	$2,353,896

(a) This figure, is by some mistake, stated to be 29.980 in the books of the Customs Dept.

(b) The difference in these figures and those for 1878 on p. 58 s. arises from the fiscal year being taken in the latter.

PHOSPHATE.

Summary.

The total quantity of Phosphate (Apatite) exported and manufactured in this country during the year 1886 has been 20,495 tons, valued at the mines at $304,245. This tonnage is arrived at by adding to the export returns of the Customs Department the small quantity used in the manufacture of superphosphate at the Brockville works.

Production by districts.

Compared with the 1885 exports, it shews a decrease in 1886 of 8,474 tons, and of $157,740 in the value at the mines.

The quantity of Phosphate stated above was partly mined in the Quebec district, and partly in the Ontario district, as follows:—

Quebec................ 19,435 tons
Ontario...... .... 1,060 "

The shipments by rail from Buckingham and from Templeton, obtained through the courtesy of Mr. J. A. Houston, Contracting Freight Agent, C.P.R., together with the shipments by water from Templeton, kindly sent us by Messrs. McLaurin and Blackburn, give a total of 20,195 tons for the Quebec district. This indicates that a small stock of about 760 tons must have been left over in Montreal at the end of 1886, on account, probably, of the very high ocean freights then ruling.

Exports.

EXPORTS OF PHOSPHATE (APATITE) FROM 1877 TO 1886.

YEARS.	ONTARIO (a.)		QUEBEC.		TOTAL.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1877	?	?	2,823	$47,084	2,823	$47,084
1878	824	$12,278	9,919	195,831	10,743	208,109
1879	1,842	20,565	6,604	101,470	8,446	122,035
1880	1,387	14,422	11,673	175,664	13,060	190,086
1881	2,471	36,117	9,497	182,339	11,968	218,456
1882	568	6,338	16,585	332,019	17,153	338,357
1883	50	500	19,666	427,168	19,716	427,668
1884	763	8,890	20,946	415,350	21,709	424,240
1885	434	5,962	28,535	490,331	28,969	496,293
1886	644	5,816	19,796	337,191	20,440	343,007
Totals..	8,983	$110,888	146,044	$2,704,447	155,027	$2,815,335

(a.) The exports from Ontario before 1878 have not been kept separately, and cannot consequently be obtained from the books of the Customs Department.

PYRITES.

The export of pyrites to the United States from Canadian mines has been in 1886, 42,906 tons, valued at the mines at $193,077, at the average price of $4.50 a ton. Exports.

The increase over 1885 was 8,783 tons, and $44,023 in value.

This quantity of pyrites was mined at the Albert and Crown Mines, Capelton, county of Sherbrooke, P.Q. The copper contents and copper value of the ore have been given on page 25 S. So far as we have been able to learn, there was no other mine worked in Canada in 1886, the ore of which was utilized for making sulphuric acid.

The following table shows the growth of the export of Canadian pyrites into the United States from 1881 to 1885, nothwithstanding the heavy import duty. These ores were the first to be used in the United States for making sulphuric acid, and have always been in great favor:

EXPORTS OF CANADIAN PYRITES TO THE UNITED STATES FROM 1881 TO 1885.

Fiscal Year.	Tons.	Duty.
1881	10,812	$29,786
1882	23,980	47,754
1883	25,211	39,879
1884	26,000	about 53,870
1885	34,123	73,734

The following tables give the quantity and the value of sulphuric acid and of the brimstone or crude sulphur imported in 1886. A small amount of pyrites was also imported, estimated at about 2,000 tons. Imports.

IMPORTS OF SULPHURIC ACID.

PROVINCES.	1885.		1886.	
	Pounds.	Value.	Pounds.	Value.
Ontario	294,139	$4,769	55,743	$ 733
Quebec	4,211	69	82,754	951
Nova Scotia	115,636	1,862	68,373	857
New Brunswick	115,570	1,718	139,644	1,589
Prince Edward Island	....	....	2,045	24
Manitoba	886	17	194	4
British Columbia	14,837	551	15,678	531
Totals	545,279	$8,986	364,431	$4,689

IMPORTS OF BRIMSTONE OR CRUDE SULPHUR.

Provinces.	1885.		1886.	
	Pounds.	Value.	Pounds.	Value.
Ontario	1,749,198	$21,505	2,225,598	$24,046
Quebec	992,475	21,749	626,005	9,797
Nova Scotia	83,144	1,699	170,571	2,641
New Brunswick	40,044	785	34,513	702
Manitoba	....	....	370	11
British Columbia	10,339	239	5,393	179
Prince Edward Island	1,232	39	929	20
Totals	2,876,432	$46,016	3,063,379	$37,396

SALT.

By Elfric Drew Ingall, Assoc. R.S.M.,
Mining Geologist to the Geological Survey of Canada.

Nearly all the salt produced in the Dominion of Canada is manufactured in Ontario, adjacent to Lake Huron, the largest number of working wells being situated in the county of Huron, whilst a few are being operated outside of this area in the counties of Lambton on the south, Bruce on the north, and Perth on the west. **Situation of wells.**

There were 19 wells working during the year 1886, six of which are located at Goderich, where the salt was originally discovered. The remainder of the works are located at the following places:—Dublin, Seaforth, Clinton, Hensall, Exeter, Blyth, Kincardine, Brussels, Courtwright, Elarton and Wingham.

Numerous other wells have been bored and "blocks" operated besides these, but are not now working, owing to the depression in the industry.

The first discovery was made at Goderich, in 1865, in a boring made there in the search for petroleum.

In 1876, Mr. Attrill put down a diamond drill-hole near Goderich, which came upon the first salt bed at a depth of 997 feet from the surface, and in a depth of 520 feet below this, the hole penetrated six salt beds aggregating 126 feet in thickness, the thinnest bed measuring six feet and the thickest, thirty-five feet.

These borings are all comprised in a strip of country about 100 miles in length, along the eastern shore of Lake Huron, and about forty miles wide.

The salt occurs at a greater depth in passing eastwards from the lake shore, a boring at Seaforth, about thirty miles south-east from Goderich, having struck salt at a depth of 1,035 feet.

The most recently bored well is at Wingham, where a bed of salt, thirty feet thick, was struck at a depth of 1,090 feet.

The process of manufacture resorted, to consists of pumping the brine from the wells, and evaporating, by artificial heat, in large pans made of boiler plate. From these the salt is raked, from time to time, as it crystallises out from the solution, the pans being only emptied at intervals for cleaning. **Process of manufacture.**

These pans are from 25 to 30 feet wide and from 100 to 150 feet long, and are heated beneath by means of a system of flues. The fuel used is mostly wood, but at a few places, coal is mixed with it or used almost entirely. A few "blocks" are run in connection with flouring and saw mills, and the brine evaporated by the waste steam from the engines.

Products made. In general, four grades of salt are made.

Land—This is any dirty salt got in cleaning the pans or otherwise. It is kept on one side, and sold to the farmers for land-dressing.

Coarse—Clean, but coarsely crystallized salt, produced by the slower evaporation which takes place at the end of the pan furthest from the fire, or when the fires get low on Sunday. This is sold for packing pork and fish, or ground to make *dairy*.

Fine—This constitutes the great bulk of the product, and is of much finer grain than the last, being crystallised much smaller, from being evaporated more quickly.

Dairy—This is produced either by grinding the coarser salts, or crystallised very small by rapid evaporation.

Packages employed. The great bulk of the salt marketed is put up in barrels, which are supposed to hold 280 lbs. of salt. They cost from 20c. @ 25c. each, and at 7 1-7 bbls. to the ton, constitute a charge of \$1.43 @ \$1.78 per ton for packages. Some makers put up their product in sacks and small bags, which often cost more than the contained salt.

Brines. The brines vary in strength from 95° to 100° of the salometer, or in general compare very favourably in regard to strength and purity with the brines of other salt districts of the continent. Of late, however, it is stated that the wells in one part of the district have been giving a rather more impure brine, which yields a salt more largely charged with the deleterious earthy chlorides.

Statistics. The following table shews the quantity and the value of the salt made and sold by the Canada Salt Association during its existence:

SALES OF SALT (Lake Huron district.)

TABLE A.

YEAR.	Quantity.	Value.
	Tons.	\$
Ending 28th March, 1883....	40,121	233,091
" " " 1884....	35,724	218,269
" " " 1885.....	30,711	167,171

These figures do not include local sales of land and other salt. The association of the salt manufacturers was discontinued at the end of March, 1885.

The following table gives the total sales of salt for the Lake Huron district, computed as explained below :—

SALES OF SALT OF ALL GRADES.—LAKE HURON DISTRICT.

TABLE B.

Years.	Barrels. (280 lbs.)	Tons.	Value.	Average Value per Ton.	Approximate Value of Packages. $
Ending 28 March 1883...	315,236	44,133	$256,400	$5.80	Not included in figures given.
" " 1884...	280,685	39,296	240,096	6.10	"
" " 1885...	241,300	33,782	183,888	5.45	"
" 31 Dec. 1886...	445,421	62,359	227,195	3.65	66,813

Note.—The figures in this table are obtained by adding 10 per cent to the figures given in Table A for 1883, 1884 and 1885, to represent the estimated amount of local sales not given in these figures. The items for 1886 are made up from the returns of the manufacturers themselves made to this office.

There is some reason to believe that the figures given above for 1886, are too high, as a discrepancy appears on comparing the amount above given with the quantities known to have been shipped from this district over the railways, and entered for export at the shipping ports. This discrepancy amounts to some 12,000 tons, and may be partly accounted for under the following heads.—Local sales in the immediate vicinity of the works which, however, in the opinion of some of the leading makers, do not probably amount to more than 3000 tons. This would represent sales of land salt and a certain quantity of the finer grades. Besides this, a considerable quantity must leave Goderich and Kincardine direct by water, to supply all the fisheries of the Lakes, and also for shipment to the North-west, being transfered to the Canadian Pacific Railway, at Port Arthur. It seems doubtful, however, if these are sufficient to account for the whole discrepancy.

That there has been an increase in the sales of salt from this district in 1886, is shewn by the following figures which give the shipments over the Grand Trunk Railway for the past few years.

TABLE C.

Salt Shipped by Rail—L. Huron District—G. T. Ry.	
Years.	Tons.
1883......	35,961
1884......	34,850
1885......	38,600
1886......	41,577

The greater facility of purchase due to the great fall in price on the dissolution of the Salt Association on 28th March, 1885, has evidently led to much larger sales. This condition of things existing during the last three-quarters of 1885, makes the total of shipments for that year high, and the discrepancy between that and the succeeding year, much less than that shewn in Table B.

Tables D., E., F., G. and H., given below, shew the state of the industry, at intervals, as far back as 1871, thus giving as complete a record of the past as it is possible now to obtain.

The study of tables D. and E. will shew that the quantity of salt manufactured in the Dominion, outside of the Lake Huron district, is very small, there being in 1881 only four works elsewhere, employing eight hands, and producing only $1,400 worth of salt. From this it will be seen that the history of the salt industry in the Lake Huron district, as herein given, is practically identical with that for the whole Dominion.

SALT WORKS.—CENSUS 1871.

TABLE D.

District.	Number of Works.	Hands Employed. Over 16. Men.	W.	Under 16. B.	G.	Yearly Wages.	Value of Raw Material.	Value of Articles Produced.	
Huron, S., Ont	8	89	..	..	..	$30,290	$ 9,475	$ 59,596	L. Huron Dis.
" N. "	7	74	..	..	..	27,200	8,750	53,517	
Bruce, S. "	1	12	..	..	..	3,500	1,500	6,886	
Yarmouth, N. S	1	5	4	..	..	1,800	4,000	16,000	
Cumberland, "	1	1	..	..	..	240	210	600	
GRAND TOTALS, 1871.									
Ontario	16	175	..	..	..	60,990	19,725	119,999	
Nova Scotia	2	6	4	..	..	2,040	4,210	16,600	
Total	18	181	4	..	..	$63,030	$23,935	$136,599	

SALT WORKS.—CENSUS 1881.

TABLE E.

District.	No.	Hands Employed. Over 16. Men.	Over 16. W.	Under 16. B.	Under 16. G.	Yearly Wages.	Value of Raw Material.	Value of Articles Produced.	No. of Bbls.	Capital Invested.
Cumber'd, NS	1	2	..	..	..	$ 150	$ 25	$ 150	....	....
Kings, N.B..	1	2	..	..	..	180	300	600	....	....
Toronto	1	1	..	1	..	125	225	400	....	....
Perth, S ...	1	12	..	..	..	4,500	30,000	50,000	....	Lake Huron District.
Huron, S ...	1	25	..	..		5,625	10,000	22,000	....	
do. C ...	19	151	..	5	10	53,837	107,375	265,398	340300	
do. N ...	1	15	..	..	..	5,000	5,000	20,000	45000	
Bruce, S ...	1	16	..	2	..	6,000	15,000	33,000	80000	
Lambton, S .	1	3	..	..	..	3,000	....	4,000	6700	
Essex	1	2	..	..	..	100	100	300	....	....

GRAND TOTALS, 1881.

District.	No.	Men.	W.	B.	G.	Yearly Wages.	Value of Raw Material.	Value of Articles Produced.	No. of Bbls.	Capital Invested.
Nova Scotia.	1	2	..	..	..	150	25	150	..	50
N. Brunswick	1	2	..	..	..	180	300	600	..	200
Ontario	26	225	..	8	10	78,187	167,700	395,098	..	297,850
Total....	28	229	..	8	10	$78,517	$168,025	$395,848	..	$298,100

QUANTITY AND VALUE OF SALT OF ALL GRADES MADE IN THE YEARS 1872–1873.

TABLE F.

YEARS.	Barrels. (280 lbs.)	Tons.	Value.	Average value per ton.	Approx. value of containing packages @ 20c.
1872	361,348	50,589	$288,909	$5.71	67,927
1873	473,290	66,261	444,578	6.71	90,315

This table is compiled from figures given in Mr. Lionel Smith's Report on the Salt industry, Geological Survey of Canada. Report of Progress 1874-75.

Mr. Smith's Report also gives the following items, which have been arranged in tabular form below.

CAPITAL AND LABOUR EMPLOYED, 1873.

TABLE G.

Kind and No. of works.		Capital Invested.	Hands Employed	Wages paid per season.
With wells..........	16	$555,000	298	$70,325
Without wells......	5	45,000	64	15,537
Table salt factories .	3	24,000	22	3,662
Totals.........	24	$624,000	384	$89,524

CONSUMPTION OF WOOD, 1873.

TABLE H.

No. of works.	Cords of wood.	Value.
21	50,635	$143,096

Present state of the industry.

The industry is at present much depressed, for although, as shewn, a larger quantity has been sold than in past years, the prices obtained have been so low as to leave a very narrow margin of profit. In 1872-3, Mr. Smith's report gives the average price of the barrel of salt as 86c. and 95c., whilst at present, 50c. is the highest price it brings; and when from this we deduct 20c. as the least cost of the barrel itself, only 30c. is left as the value of the contents, the cost for fuel, wages, commissions, &c., amounting to close on this figure.

There being no standard legally fixed for the size of the barrel, the quantity is apt to vary; the barrel being taken as the unit of sale, there is a great temptation for the manufacturers to make up for low prices by giving less weight, a temptation which does not appear to be always resisted, so that the barrel of salt sold does not always contain its supposed complement of 280 lbs.

Neither is there, as in the neighbouring salt district of Michigan, any legal obligation to give the public an article which has been properly dried by draining for a fixed period of time; and further, the absence of a proper system of inspection, necessarily leads to varia-

tions in the purity of the material put on the market. It has been stated, in this connection, that some of the salt sold contains a deleterious proportion of the deliquescent earthy chlorides, but of course nothing can be definitely asserted on this point, without making a complete series of analyses of a number of carefully collected samples.

The industry, as before stated, is certainly much depressed, but as to the precise remedy for this, the manufacturers differ.

A great many of them think that a system of government inspect on would do good; others lay more stress upon the necessity for the standard content of a barrel being legally fixed. Were both of these arrangements made, it would undoubtedly be beneficial, as putting all the competing manufacturers upon a fair and equitable basis, and ensuring to the public a standard quantity and quality.

Another thing which militates against the Canadian salt industry is the competition of English salt coming in duty free, and with discriminatory freight rates in its favour. Even were this removed, there would remain the natural disadvantage of the distance of the chief market for salt in the Dominion, *i. e.*, the sea fisheries, from the centre of production, the cost of carrying the salt over such long distances, doubling, or more than doubling, its price at the point of consumption.

The discrimination mentioned in favour of the competing English salt arises from the fact that both the railways and steamship lines can afford to carry material moving west at a very much lower rate than that moving east. In fact, a large quantity of English salt comes out to Montreal as ballast, paying either none or a mere nominal freight charge.

These various causes limit the Canadian salt manufacturers market practically to Ontario, a demand too limited for the capacity of even the present works, most of which consequently only work for a few months in the year.

The large area underlain by the salt, coupled with the great facilities for starting numbers of new works, not to speak of the large reserve capacity of the present ones, would enable this district to supply all the salt demand of the Dominion for years to come.*

Tables J, K, L, M, N and O, speak for themselves. Table O shews that large quantities of salt, not produced in Canada, are exported. This is probably English salt coming out in vessels bound for Canadian ports, as ballast, &c., and shipped through to the United States. Imports and exports.

* For further particulars respecting the geology of the Lake Huron salt region, analyses of brines, &c., &c. See Reports of Progress of the Geological Survey of Canada, 1866-9, 1874-5 and 1876-7.

Tables J, K, L, N and O, are compiled from figures obtained from the Department of Customs, Ottawa.

IMPORTS OF SALT (DUTY FREE) FOR FISHERIES.

TABLE J.

Provinces.	1885. Pounds.	1885. Value.	1886. Pounds.	1886. Value.
Ontario	8,176,239	$13,307	6,230,657	$10,159
Quebec	84,505,625	125,709	60,465,880	79,687
Nova Scotia	44,994,639	67,742	103,153,827	140,458
New Brunswick	36,985,231	60,815	30,679,640	49,519
Prince Edward Island	8,671,320	9,326	7,199,160	8,165
Manitoba	111,552	255	133,168	935
British Columbia	712,320	1,118	672,000	1,458
Totals	184,156,926	$278,272	208,534,332	$290,381

IMPORTS OF COARSE SALT PAYING DUTY.

TABLE K.

Provinces.	1885. Cwts.	1885. Value.	1886. Cwts.	1886. Value.
Ontario	699,535	$1,948	855,000	$2,177
Nova Scotia			600	4
British Columbia	12,732	47	10,336	38
Totals	712,267	$1,995	865,936	$2,219

IMPORTS OF FINE SALT, PAYING DUTY.

TABLE L.

PROVINCES.	1885.		1886.	
	Pounds.	Value.	Pounds.	Value.
Ontario	1,499,432	$ 6,852	688,211	$ 2,431
Quebec	6,133,505	13,810	6,564,801	24,994
Nova Scotia..................	596,382	2,154	302,688	1,093
New Brunswick	1,466,480	4,433	1,800,890	6,177
Prince Edward Island........	46,680	145	29,698	76
Manitoba	2,700	26	50,300	230
British Columbia.............	861,949	3,559	1,311,040	5,606
Totals...............	10,607,128	$30,979	10,747,628	$40,607

EXPORTS OF SALT FROM CANADA TO THE UNITED STATES.

TABLE M.

Year ending 30th June	Nova Scotia, New Brunswick, Prince Edward Island.			Quebec, Ontario, Manitoba, North-west Territory.		
	Pounds.	Bushels.	Value.	Pounds.	Bushels.	Value.
1883	3,053,608	54,528	$7,555	28,853,886	515,243	$79,514
1884	6,586,508	117,616	13,694	17,878,254	319,254	60,605
1885	2,180,200	38,932	4,573	11,226,236	200,468	34,954
1886	3,678,418	65,686	7,901	25,187,862	449,783	5,286

Year ending 30th June	British Columbia.			Total.		
	Pounds.	Bushels.	Value.	Pounds.	Bushels.	Value.
1883	14,760	264	$120	31,922,254	570,040	$87,189
1884	25,180	450	155	24,489,942	437,320	74 454
1885	122,810	2,193	612	13,529,246	241,593	40,139
1886	73,387	1,310	130	28,939,667	516,779	53,317

NOTE.—Figures taken from the annual publications relating to Imports and Exports issued by the U. S. Treasury Department.

TABLE N.—EXPORTS OF SALT, THE PRODUCE OF CANADA

Year.	Ontario.		Quebec.		Nova Scotia.		New Brunswick.		Manitoba.		British Columbia.		Prince Edward Island.		Total.	
	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.
1873	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1874	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1875	541,669	$66,512	1,089	$312	...	...	42	$10	...	...	...	...	...	...	542,800	$66,834
1876	905,522	83,215	3,833	939	...	...	...	...	...	...	...	...	...	...	909,355	84,154
1877	702,494	59,992	2,150	685	...	...	...	...	...	...	...	...	...	...	704,644	60,677
1878	403,798	36,004	3,297	1,023	...	...	...	...	...	...	...	...	...	...	407,095	37,027
1879	587,805	48,560	2,616	731	345	$76	...	...	...	...	...	...	...	...	590,766	49,367
1880	464,661	45,366	1,887	605	1,093	240	...	...	...	...	...	...	...	...	467,641	46,211
1881	336,608	43,121	6,600	1,506	...	...	...	...	...	...	...	...	...	...	343,208	44,627
1882	181,007	18,170	751	180	...	...	...	...	...	...	...	...	...	...	181,758	18,350
1883	199,733	19,492	...	...	...	...	...	...	...	...	...	...	...	...	199,733	19,492
1884	167,029	15,291	...	...	...	...	...	...	...	...	...	...	...	...	167,029	15,291
1885	246,584	18,721	210	35	...	...	...	...	...	...	...	...	...	...	246,794	18,756
1886	224,595	16,816	...	...	240	40	90	25	...	...	...	...	18	$5	224,943	16,886

EXPORTS OF SALT NOT THE PRODUCE OF CANADA.

Year.	Ontario.		Quebec.		Nova Scotia.		New Brunswick.		Manitoba.		British Columbia.		Prince Edward Island.		Total.	
	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.
1873	152,475	$38,171	108,560	$26,338	120,312	$20,259	36,605	$9,140	...	...	...	...	6,495	$1,481	424,447	$95,389
1874	169,925	38,018	40,818	11,775	98,681	22,684	31,061	7,634	...	...	...	...	17,867	4,688	359,252	84,749
1875	85,985	17,821	7,823	2,581	71,978	19,189	17,509	4,004	...	...	103	$68	18,110	5,650	201,518	49,318
1876	49,679	14,842	7,604	1,626	78,807	18,002	26,259	4,452	...	...	210	121	14,874	3,585	177,433	42,578
1877	41,932	8,902	5,590	973	38,190	7,684	13,020	2,237	...	...	177	88	7,579	2,028	106,488	21,912
1878	106,106	23,919	136,602	42,878	31,147	6,679	15,792	2,268	...	...	475	266	5,768	1,831	294,980	77,841
1879	112,340	81,239	29,905	12,231	88,255	7,999	18,103	2,898	...	...	530	264	...	...	199,133	54,631
1880	149,423	36,236	404,902	47,562	84,506	14,895	18,660	3,147	...	...	...	...	1,600	500	689,1[illegible]1	102,840
1881	22,112	4,639	95,830	38,105	39,513	7,875	34,560	5,437	...	...	...	...	546	109	192,561	56,165
1882	400	200	17,131	6,245	57,610	12,790	30,880	4,835	...	...	1,084	409	450	84	107,555	24,563
1883	6,547	1,063	20,442	3,412	106,922	21,900	50,584	10,619	...	...	714	280	...	...	194,209	88,174
1884	...	...	10,022	3,729	39,461	8,523	24,567	3,751	...	...	443	112	...	...	74,493	16,115
1885	...	...	5,838	1,928	80,612	6,834	106,340	7,265	...	...	...	...	355	78	143,135	15,600
1886	...	...	3,448	800	48,677	8,683	27,308	5,018	...	...	...	...	330	62	74,851	14,568

SILVER.

By ELFRIC DREW INGALL, Associate R. S. M.
Mining Geologist to the Geological Survey of Canada.

The following tables, compiled from the books of the Customs **Exports.** Department at Ottawa, give a record of the exports of silver ore from Canada for the past sixteen years:—

EXPORTS OF SILVER ORE FROM 1871 TO 1873.

Fiscal Year.	Ontario.	British Columbia.	Total.
1871	$595,261	$.......	$595,261
1872	1,087,839	803	1,088,642
1873	1,376,060	(*a*) 3,320	1,379,380
Total.	$3,059,160	$4,123	$3,063,283

(*a*) Probably from near Fort Hope.

EXPORTS OF SILVER ORE FROM 1873 TO 1886, INCLUSIVE.

Year.	Ontario.	Quebec.	New Brunswick.	Manitoba.	British Columbia.	Total.
1873	$1,241,598	$......	$......	$......	$2,160	$1,243,758
1874	493,163	......	......	.....	300	493,463
1875	472,092	......	......	......	900	472,992
1876	354,178	......	......	......	......	354,178
1877	33,722	8,626	500	......	......	42,848
1878	665,665	50	......	......	......	665,715
1879	154,273	......	......	......	......	154,273
1880	65,205	3,000	......	......	......	68,205
1881	15,105	......	......	......	10	15,115
1882	6,505	200	......	......	......	6,705
1883	8,620	......	......	......	......	8,620
1884	13,300	......	......	......	......	13,300
1885	28,801	......	117	258	......	29,176
1886	16,505	(*a*) 8,000	......	1,452	......	25,957
Total..	$3,568,732	$19,876	$617	$1,710	$3,370	$3,594,305

(*a*) Probably from Thunder Bay District.

Production of Lake Superior mines.

The figures given ought to be identical with the production year by year, as all such ores are exported, finding their market either in the United States or in England, so far, chiefly in the former country.

The Lake Superior district has been, and still is, the chief and almost only centre of production of the ores of this metal in Canada, and for many years, Silver Islet mine was the only producer in that district. Even during the operation of the other mines, their product was quite small compared with that of this one.

For this reason, the exports of silver ore from Ontario ought to agree with the figures in the following table:—*

SILVER ISLET MINE.

Year.	Product.
	$
Before 1871........	115,269
1871........	648,132
1872........	372,892
1873........	347,716
1874........	300,026
1875........	175,083
Total........	1,959,118

Discrepancy.

It will be observed, however, that there are considerable discrepancies. The total production of Silver Islet mine, from 1868, when work was commenced, to the end of 1875, was as above, but from this amount we must take $26,243, produced before the commencement of the fiscal year ending June 30th, 1871, and about $89,000 produced in the latter half of 1875, in order to enable us to compare it with the amounts given for the fiscal years in the Trade and Navigation Returns for that period, which are as follows:—

Silver exported from Ontario during fiscal years 1871-75 inclusive....................	$3,910,438
Production of Silver Islet during the same period..................................	1,843,875
Difference................................	$2,066,563

Only four other silver mines were worked to any extent in the first period of the history of silver mining in the Lake Superior region, viz., the Beck; 3 A.; Thunder Bay, and Shuniah, or Duncan Mines. Of these, the first three were worked at intervals from 1866 to 1874, whilst the latter was worked with various stoppages from 1867 to 1881. I have not, so far, been able to get any returns of the shipments year by year, from these mines, but their total product from commencement to close would, I think, be well covered by $30,000. There is thus left a dis-

* From Paper on Silver Islet by Thomas Macfarlane, Trans. American Institute of Mining Engineers, Vol. VIII.

crepancy of over $2,000,000 up to the end of 1875, which I have as yet been unable to account for.

Silver Islet mine was closed in the spring of 1884, but I have not, so far, been successful in obtaining figures of its yield year by year since 1875.

Previous to the operations ceasing, the Rabbit Mountain Mine had been started in 1883, and this was followed by the discovery of the others of that group of silver mines at present working in the Thunder Bay region. Shortly after this again, the Silver Mountain group of argentiferous lodes was discovered in the same district.

Some of the mines are at present being worked, and are affecting the production in a varying, but continuously increasing, degree.

Total discrepancy in the available returns.

On comparing the export returns for Ontario to the end of 1886, as shewn in the above tables, with the quantity known to have been produced by all the Lake Superior silver mines to date, a discrepancy again appears, as shewn below :—

Produced by Silver Islet, from its commencement to its close..................................	$3,250,000
Produced by the Shuniah group of mines, from their commencement to their close, say..........	30,000
Produced by the Rabbit Mt. and Silver Mt. groups of mines from their commencement to the end of 1886..	69,338
	$3,349,338

Against this total we have $6,627,892 shewn in the tables, p. 73 s, as exported from Ontario during this period, leaving a difference of $3,288,554. Part of this would be accounted for by the overlapping of the returns of six months in the change from fiscal to calendar years, but making allowance for that, it would still leave about $3,000,000 to be accounted for, which we have at present no means of doing.*

The exports of silver ore from Quebec given in the tables, are probably often referable to small lots of ore from the Lake Superior region passing out by way of Montreal, whilst the items given for the other provinces are probably small lots of ore sent through at various times from mines in process of being tested in those districts.

Besides the silver produced in Canada, and exported in the form of silver ores proper, a large quantity of the metal is sent out in a shape which would not bring it under that head in the Customs' entries. I refer to the silver contained in the copper ores exported from the Capelton group of mines in Quebec. This has been estimated at about $167,000 for 1886.

* An investigation of the entries in the books of the Customs Department seems to show that the greater part of the silver ore entered as exported from Ontario was produced in the Lake Superior region. If this is so, it shews that the statistics of the silver ore production of that region, as gleaned from different sources, vary greatly. It is believed that the above figure, viz. :—$3,349,338, based on data obtained by direct enquiry in the district is very nearly correct, and that the discrepancy is to be accounted for on the supposition that the values declared to the Customs officers have been continually over-estimated.

STRUCTURAL MATERIALS.

Ornamental Stones.

Granite.—The production in 1886, as reported to this office, from nine different quarries, is 6,062 tons, valued in the rough state at the quarries at $63,309. We believe that this represents very nearly the whole production of Canada. New Brunswick was the largest producing province with 2,522 tons of a spot value in the rough of $31,509.

Marble and Serpentine.—The returns from four quarries were 501 tons valued, in the rough state but quarried to sizes, at $9,900; this is not a complete statement of the total production.

Imports.—The value of the imports of marble and of manufactures of stone or granite, N. E. S., (as classified in the books of the Customs department,) will be found in the following tables:

VALUE OF IMPORTS OF MARBLE.

PROVINCES.	1885.		1886.	
	Blocks, &c.	Slabs Sawn.	Blocks, &c.	Slabs, Sawn.
Ontario	$1,368	$46,559	$1,879	$44,330
Quebec	1,310	15,008	414	21,073
Nova Scotia	604	6,059	736	5,637
New Brunswick....................	170	5,430	737	6,420
Manitoba......	16	139	12	78
British Columbia..................	46	1,355	......	1,147
Prince Edward Island.............	......	2,945	......	2,683
T	$3,514	77,495	3,778	81,368
	Blocks, &c.	3,514	......	3,778
Totals..	......	$81,009	......	$85,146

VALUE OF IMPORTS OF OTHER ORNAMENTAL STONES.

Manufactures of Stones or Granite, N. E. S.	1885.		1886.	
	Value.		Value.	
Ontario........	......	$26,826	......	$28,695
Quebec.......	......	8,871	......	8,425
Nova Scotia....	......	1,141	......	1,037
New Brunswick..................	......	1,174	......	1,058
Manitoba....	......	201	......	373
British Columbia	......	905	......	1,052
Prince Edward Island	......	735	......	443
Totals........	......	$39,853	.....	$41,083

Slate.—The production in 1886, was 5,345 tons, the value of which at the quarries may be said to be $64,675. It was nearly all sold in the Canadian market, as the exports were only 34 tons; and was all quarried in the province of Quebec. So far as ascertained, there were no slate quarries worked in the other provinces. Slate and flagstone.

EXPORTS OF SLATE.

YEARS.	QUEBEC.	
	Tons.	Value.
1876	150	$3,369
1877	753	12,415
1878	30	692
1879	20	76
1880	....	....
1881	420	8,100
1882	34	1,545
1883	739	9,840
1884	539	6,845
1885	346	5,274
1886	34	495
Total	3,065	$48,651

IMPORTS OF SLATE.

PROVINCES.	1885.	1886.
Ontario	$13,920	$16,253
Quebec	8,033	8,071
Nova Scotia	1,362	1,438
New Brunswick	2,505	3,130
Prince Edward Island	81	182
Manitoba	190	329
British Columbia	202	289
Total	$26,293	$29,692

Flagstone.—The tables of exports and imports are appended. The Dudswell flagstone quarries produced in 1886 about 70,000 sq. feet: value at the quarries $7,875. No other returns of flagstones were received.

IMPORTS OF DRESSED FLAGSTONES.

PROVINCE.	1885.		1886.	
	Tons.	Value.	Tons.	Value.
Ontario...........................	1,148	$6,505	1,494	$11,513

Building Stones.

Building Stones.—The compilation of such statistics as could be reached, is given below, with the tables of exports and imports (as classified by the Customs Department).

PRODUCTION OF BUILDING STONES IN 1886.

As returned to this office, but estimated to be three to four-fifths only of the total production.

PROVINCES.	No. of Returns.	Cubic Yards.	Value.
Ontario.............................	53	117,523	283,573
Quebec.............................	17	28,312	185,340
Nova Scotia...........................	15	9,473	84,051
New Brunswick........................	3	2,728	24,970
Prince Edward Island..................	4	1,510	2,265
British Columbia.....................	2	6,231	62,310
Total..................	94	165,777	$642,509

VALUE OF EXPORTS OF STONE AND MARBLE UNWROUGHT.

Years.	Ontario.	Quebec.	Nova Scotia.	New Brunswick.	British Columbia.	Prince E'd Island	Total.
1873	$ 26,145	$ 5,487	$ 37,069	$131,368	$2,412	$	$ 202,481
1874	54,298	1,282	30,614	131,901	....	80	218,175
1875	34,108	1,741	3,184	59,060	....	10	98,103
1876	19,725	209	4,914	55,178	....	....	80,026
1877	7,969	2,836	7,372	28,639	....	....	46,816
1878	8,415	269	5,504	39,519	....	....	53,707
1879	12,496	159	11,670	26,995	....	....	51,320
1880	11,282	580	14,991	50,270	....	....	77,123
1881	10,432	932	16,407	66,287	....	....	94.058
1882	22,343	3	18,219	34,718	....	....	75,283
1883	14,111	30	14,375	23,088	....	....	51.604
1884	24,565	6	10,617	26,145	....	....	61,333
1885	14,810	......	15,575	19,703	....	....	50,088
1886	27,922	......	18,377	26,954	....	....	73,253
Totals	$288,621	$ 13,534	$ 208,888	$719,825	$2,412	$ 90	$1,233,370

VALUE OF EXPORTS OF STONE AND MARBLE, WROUGHT.

PROVINCES.	1884.	1885.	1886.
Ontario	$ 412	$ 58	$ 103
Quebec..............................	1,135	105	1,206
Nova Scotia..........................	50	2,162	121
New Brunswick......................	18,551	14,321	18,596
Totals..............	$20,148	$16,646	$20,026

IMPORTS OF BUILDING STONES.

Dressed Freestone, and all other Building stone.	1885. Tons.	1885. Value.	1886. Tons.	1886. Value.
Ontario	986	$3,949	777	$5,108
Quebec	....	16	5	185
New Brunswick	140	588	2	10
Totals	1,126	$4,553	784	$5,303
Rough Freestone, Sandstone and Building stone.				
Ontario	4,883	$28,409	7,499	$39,282
Quebec	206	1,509	202	1,909
New Brunswick	30	393	25	453
British Columbia	4	61	....	....
Totals	5,123	$30,373	7,726	$41,644

Lime and Cement.

Lime and Cement.—It is impossible, at present to estimate the proportion of the returned production to the total production, as the names of many producers were not on our lists.

LIME PRODUCTION IN 1886, AS RETURNED TO THIS OFFICE.

(Incomplete Return.)

PROVINCES.	No. of Returns	Bushels.	Value.
Ontario	49	783,450	$140,290
Quebec	16	401,700	75,700
Nova Scotia	2	16,000	3,800
New Brunswick	14	316,380	58,120
Prince Edward Island	2	11,720	2,260
Manitoba	1	2,000	460
North-West Territory	2	700	625
British Columbia	1	4,000	2,500
Totals	87	1,535,950	$283,755

VALUE OF EXPORTS OF LIME.

PROVINCES.	1884.	1885.	1886.
Ontario	$3,805	$3,660	$4,245
Quebec	367	15	12
Nova Scotia	2,252	1,668	52
New Brunswick	2,666	9,886	25,258
Manitoba	....	....	106
Prince Edward Island	....	....	9
Totals	$9,090	$15,229	$29,682

IMPORTS OF LIME.

Provinces.	1885.		1886.	
	Barrels.	Value.	Barrels.	Value.
Ontario	2,405	$1,875	2,659	$2,064
Quebec	3,823	3,099	3,115	2,269
Nova Scotia	673	648	464	438
New Brunswick	1	1	6	6
Manitoba	284	271	451	394
British Columbia	4,917	4,792	4,005	3,572
Totals	12,103	$10,686	10,700	$8,743

IMPORTS OF HYDRAULIC CEMENT.

Cement.

Provinces.	1885.		1886.	
	Barrels.	Value.	Barrels.	Value.
Ontario	4,417	$3,797	3,553	$3,408
Quebec	53	104	1,414	2,119
Nova Scotia	28	56	9	15
New Brunswick	737	787	1,576	1,840
Prince Edward Island	75	94	25	31
British Columbia	....	....	564	1,896
Totals	5,310	$4,838	7,141	$9,309

IMPORTS OF CEMENT IN BULK OR IN BAGS.

Provinces.	1885.		1886.	
	Bushels.	Value.	Bushels.	Value.
Ontario	5,666	$1,354	4,520	$1,134
Quebec	....	....	918	470
New Brunswick	150	100	....	....
Totals	5,816	$1,454	5,438	$1,604

VALUE OF IMPORTS OF PORTLAND CEMENT.

Provinces.	1885.	1886.
Ontario	$ 3,296	$ 5,049
Quebec	81,557	131,238
Nova Scotia	8,369	5,900
New Brunswick	3,086	2,999
Prince Edward Island	377	290
Manitoba	21	3
British Columbia	9,972	3,358
Totals	$106,678	$148,837

Sand and Gravel.

Sand and Gravel.—The production and home consumption of these materials could not be fairly estimated.

EXPORTS OF SAND AND GRAVEL.

Years	Ontario.		Quebec.		Nova Scotia.		New Brunswick.		Manitoba.		Total.	
	Tons.	Value.	Tons.	Value	Tons.	Value.	Tons.	Value	Tons.	Value	Tons.	Value.
1877	11,996	$ 2,141	..	..	2	$ 10	..	$	..	$	11,998	$ 2,151
1878	49,644	7,668	71	288	425	425	..	..	..	..	50,140	8,381
1879	46,909	9,078	90	360	....	....	..	..	..	..	46,999	9,438
1880	53,951	11,177	..	..	....	....	..	..	..	..	53,951	11,177
1881	58,650	15,060	..	..	10	15	17	40	7	14	58,693	15,129
1882	59,751	15,611	7	7	400	600	..	..	..	..	60,158	16,218
1883	55,346	14,065	..	..	....	....	..	..	..	..	55,346	14,065
1884	72,499	14,465	..	..	1242	5513	..	..	..	..	73,741	19,978
1885	110,058	20,504	..	..	603	2374	..	..	.	..	110,661	22,878
1886	124,662	23,902	..	..	200	200	3	124	..	..	124,865	24,226
Tot'ls	643,475	$133,671	168	$655	2882	$9137	20	$164	7	$14	646,552	$148,641

IMPORTS OF SAND AND GRAVEL.

PROVINCES.	1885 (a)		1886	
	Tons.	Value.	Tons.	Value.
Ontario	6,369	$15,304	11,298	$15,002
Quebec	4,652	5,137	5,794	6,191
Nova Scotia	182	1,052	1,307	4,015
New Brunswick	507	1,007	906	1,120
Manitoba	35	80	30	83
British Columbia	114	140	27	45
Totals	11,859	$22,728	19,362	$26,456

(a) Ontario quantity for this year incomplete (only 2nd half of the year.)

Bricks and Tiles.—It is estimated that the figures in the two following tables represent about three-fourths of the total production. Bricks and Tiles.

Returns were also received of $112,910 worth of miscellaneous clay products such as glazed sewer pipes, pottery, ornamental bricks, fire-bricks, bath-bricks and pressed paving stones, which were manufactured in the country in 1886.

PRODUCTION OF BRICKS DURING 1886, AS RETURNED TO THIS OFFICE.
(Incomplete return)

PROVINCES.	No. of Returns.	Thousand.	Value.
Ontario	188	103,928	$631,892
Quebec	23	14,175	83,025
Nova Scotia	16	7,190	50,630
New Brunswick	14	5,957	30,908
Prince Edward Island	8	1,640	12,120
Manitoba	4	1,350	14,475
North-West Territory	3	800	9,400
British Columbia	5	4,305	41,150
Totals	261	139,345	$873,600

PRODUCTION OF TILES DURING 1886, AS RETURNED TO THIS OFFICE, (incomplete return).

Provinces.	No. of Returns.	Thousand.	Value.
Ontario	74	12,139	$139,307
New Brunswick	7	177	2,310
Prince Edward Island	1	100	1,000
Totals	82	12,416	$142,617

IMPORTS OF BUILDING BRICKS.

Provinces.	1885,		1886,	
	Thousand.	Value,	Thousand.	Value.
Ontario	1,508	$6,128	213	$1,269
Quebec	294	2,847	119	1,133
New Brunswick	6	40	13	59
Nova Scotia	3	18	2	11
Prince Edward Island	....	....	3	57
Manitoba	51	1,043	....	....
Totals	1,862	$10,076	350	$2,529

IMPORTS OF DRAIN TILE AND GLAZED SEWER PIPE.

Provinces.	1885.	1886.
Ontario	$31,164	$45,706
Quebec	13,778	8,510
Nova Scotia............	325	....
New Brunswick.........	1,283	979
Prince Edward Island....	....	16
Manitoba	1,536	506
British Columbia........	1,743	654
Totals	$49,829	$56,371

IMPORTS OF FIRE CLAY.

Provinces.	1885 (a)		1886.	
	Cwts.	Value.	Cwts.	Value.
Ontario	11,345	$5,945	20,750	$5,033
Quebec	30,286	4,338	78,863	10,273
Nova Scotia	1,246	1,474	2,152	704
New Brunswick	983	172	780	84
Manitoba	130	130	240	120
British Columbia	414	211	750	330
Prince Edward Island	54	29	90	27
Totals	44.458	$12,299	103,625	$16,571

(a) Ontario and Nova Scotia quantities for this year are incomplete.

IMPORTS OF OTHER CLAYS N. E. S.

Provinces.	1885.		1886.	
	Cwts.	Value.	Cwts.	Value.
Ontario	3,720	$5,108	16,369	$3,238
Quebec	18,358	2,953	12,787	1,553
New Brunswick	2,176	237	13,203	279
Totals	24,254	$8,298	42,359	$5,070

IMPORTS OF FIRE BRICKS, TILES, &c.

Provinces.	1885.	1886.
Ontario	$18,611	$23,887
Quebec	18,971	25,903
Nova Scotia	3,890	4,216
New Brunswick	4,975	6,735
Prince Edward Island	134	41
Manitoba	279	79
British Columbia	1,454	1,226
Totals	$48,314	$62,087

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GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA,

FROM THE

LABORATORY OF THE SURVEY.

BY

G. CHRISTIAN HOFFMANN, F. Inst. Chem., F.R.S.C.,
Chemist and Mineralogist to the Survey.

ASSISTANTS:

F. D. ADAMS, M.Ap.Sc.
E. B. KENRICK, B.A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.

1887.

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I have the honor of herewith laying before you my Report upon the work carried out in the Laboratory of this Survey since the date of my last. During the period embraced by this report, seven hundred and twenty-one mineral specimens were received—brought or sent—for identification or for information in regard to their possible economic value. This entailed a very appreciable amount of work, the nature of which was, in the main, of no great interest except to those immediately concerned. Only such examinations and analyses are here recorded as were deemed likely to prove of general interest.

Mr. F. D. Adams having been for about the space of nine months engaged in the discharge of other duties, in connection with the Indian and Colonial Exhibition, the time devoted by him to chemical work was necessarily very limited. A very large proportion of the results here formulated were obtained by Mr. E. B. Kenrick.

Such examinations or analyses as were carried out by these gentlemen have in all instances been duly credited to them: those not otherwise designated were made by myself.

I have the honor to be,

Sir,

Your obedient servant,

G. CHRISTIAN HOFFMANN.

OTTAWA, December 31, 1886.

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA,

FROM THE

LABORATORY OF THE SURVEY.

MISCELLANEOUS MINERALS.

Native Platinum.

The earliest reference to the finding of native platinum in Canada is that by Dr. T. Sterry Hunt, in the Report of Progress of the Geological Survey of Canada for the year 1851-2, p. 120. He there mentions that it had been observed by him, in association with osmiridium, in the gold washings of the Rivière du Loup; likewise, that specimens had been submitted to him which were reported to have been found under like conditions in the Rivière des Plantes, which, together with the preceding locality, is in the county of Beauce, Province of Quebec. Native platinum. Localities of occurrence of, in the Province of Quebec.

It has since been met with, according to Dr. G. M. Dawson, in association with alluvial gold, in several of the streams of British Columbia, not the least noticeable in this regard being that from which the specimen under consideration was obtained, viz., Granite Creek, a branch of the Tulameen or North Fork of the Similkameen River. This specimen, which was presented to the Survey by T. Elwyn, Esq., Deputy Provincial Secretary of British Columbia, has been examined by me, and with the results hereinafter stated. Localities of occurrence of, in British Columbia.

It weighed 18·266 grams, of which 17·894 grams consisted of native platinum and the remainder of rock-matter, magnetite, a little pyrite, and a few flakes of native gold. The material being made up as follows:— Analysis of specimen of, from Granite Creek, British Columbia.

Native platinum	97·963
Gold	0·225
Pyrite	0·219
Rock matter	1·593
	100·000

Analysis of specimen of native platinum from Granite Creek, British Columbia, cont.

The platinum was in the form of grains and pellets varying in size from half a millimetre to eight millimetres in diameter, and in weight from three milligrams to eight decigrams. The grains measuring less than one millimetre constituted but a very small proportion of the whole, there were only a few pellets measuring five millimetres, and but two measuring eight millimetres, the bulk of the material being made up of grains varying in size from one to four millimetres in diameter. The grains, which were all very much rounded off as though from attrition, had a lead-grey color and sub-metallic lustre, they were all more or less tarnished, and the greater number contained inclusions of chromite. A certain proportion of the same proved to be readily attracted by the magnet, and of these all such as were tried were found to possess polarity. After treatment with dilute hydrochloric acid, which removed a little iron, the grains had a steel-grey color and metallic lustre. The particles of foreign matter having been carefully eliminated, the material, as a whole, was found to have a specific gravity (temp. 15·5° C.) of 16·656.

The ore was separated by means of the magnet into two distinct portions, a non-magnetic and a magnetic; the latter constituted 37·88 per cent., by weight, of the whole.

Portion I.—Non-Magnetic.

This weighed 11·115 grams and had a specific gravity (temp. 15·5° C.) of 17·017. The grains and pellets conposing it were of very irregular shape: about one-third, by weight, of the same had comparatively smooth surfaces, and were apparently quite free from any foreign inclusions, the remainder were all more or less pitted, and in most instances contained a little imbedded chromite. For the purpose of analysis, this material was divided into several sub-portions. Adding together the weights of the material constituting each sub-portion, as likewise those of each of the various constituents found, calculation showed the composition of this portion of the ore, as a whole, to be as follows:—

Platinum	68·19
Palladium	0·26
Rhodium	3·10
Iridium	1·21
Osmium	—
Copper	3·09
Iron	7·87
Osmiridium	14·62
Gangue (imbedded chromite)	1·95
	100·29

The osmiridium was partly in the form of minute steel-grey colored scales of bright metallic lustre, and partly as a heavy, light steel-grey colored powder; there were also a few small, tolerably firm, skeleton aggregations of minute scales, likewise some minute, almost microscopic, tin-white grains, and some six or seven tin-white, cavernous nodules varying in size from two to three millimetres in diameter. The grains and nodules, which amounted to about fifty-five per cent. of the whole, had a specific gravity of 18·742 (15·5° C.)

Analysis of specimen of native platinum from Granite Creek, British Columbia, cont.

Portion II.—Magnetic.

Weighed 6·779 grams, had a specific gravity (temp. 15·5° C.) of 16·095, and was, as already stated, magneti-polar. The grains and pellets composing it were, as in the previous instance, of very irregular shape: very few had perfectly smooth surfaces, by far the greater number being more or less pitted and containing inclusions of chromite. This material was, for the purpose of analysis, divided into two sub-portions. Adding together the weights of the material comprising these two sub-portions, also the amounts found of each of the several constituents, calculation showed this portion of the ore, as a whole, to contain:—

Platinum	78·43
Palladium	0·09
Rhodium	1·70
Iridium	1·04
Osmium	—
Copper	3·89
Iron	9·78
Osmiridium	3·77
Gangue (imbedded chromite)	1·27
	99·97

The osmiridium was in this instance present, exclusively, in the form of minute, thin, shining, steel-grey colored scales.

On comparing the analysis of the non-magnetic with that of the magnetic portion, it will be seen that the latter contained much less palladium and rhodium and very considerably less included osmiridium, but contained somewhat more copper, nearly two per cent. more iron, and a little over ten per cent. more platinum than the former. That the magnetic property of Portion II. was dependant upon the amount of iron which it contained may be questioned, in view of the fact that one of the sub-portions of the non-magnetic portion, and which was not in the slightest degree magnetic, contained 8·90 per cent. of iron, whereas one of the sub-portions of Portion II.,

Analysis of specimen of native platinum from Granite reek, British Columbia, cont.

and which was found to be magneti-polar, contained but 9·35 per cent. of iron, a difference of only 0·45 per cent.

The weights of the material constituting the sub-portions having been added together, as likewise the amounts of each of the several constituents found in these sub-portions, calculation showed the composition of this ore—after careful separtion of the associated grains of foreign matter—taken as a whole, as determined upon the 17·894 grams material, to be as follows:—

Platinum	72·07
Palladium	0·19
Rhodium	2·57
Iridium	1·14
Osmium	—
Copper	3·39
Iron	8·59
Osmiridium	10·51
Gangue (imcedded chromite)	1·69
	100·15

In common with the native platinum of Oregon and Australia, this ore contains a large proportion of osmiridium, but differs from the material of those localities in that it contains a higher percentage of copper and iron, in which regard it more nearly approaches in composition to some Russian specimens of this mineral.

Analysis of platinum ore from Oregon, Australia, California, Choco, and Nischne Tagilsk.

The following analyses of platinum ores, by Deville and Debray, are given for comparison with the foregoing, from which, it must be remembered, the associated gold was separated prior to analysis:—

	1	2	3	4	5
Platinum	51·45	61·40	85·50	86·20	76·40
Palladium	0·15	1·80	0·60	0·50	1·40
Rhodium	0·65	1·85	1·00	1·40	0·30
Iridium	0·40	1·10	1·05	0·85	4·30
Copper	2·15	1·10	1·40	0·60	4·10
Iron	4·30	4·55	6·75	7·80	11·70
Gold	0·85	1·20	0·80	1·00	0·40
Osmiridium	37·30	26·00	1·10	0·95	0.50
Sand	3·00	1·20	2·95	0·95	1·40
	100·25	100·20	101·15	100·25	100·50

1. Oregon, North America. 2. Australia. 3. California, North America. 4. Choco, South America. 5. Nischne Tagilsk, Ural, Russia.

Platinum, economic uses of.

Platinum is, by reason of its inalterability at high temperatures and power of resisting the action of a great number of the most powerful chemical agents, a valuable and useful metal for the manufacture of a

great many forms of chemical apparatus, such as retorts, crucibles, evaporating dishes, etc., etc. Large platinum vessels are also used in manufacturing operations on the large scale, more especially in the form of stills for the concentration of the acid in sulphuric acid works. Osmiridium is employed for tipping the nibs of gold pens, constituting the so-called "diamond point." For this purpose it is necessary that it should be in the form of natural grains, and these are very carefully selected, the requirements being that they should be solid, compact, and of the proper size and shape. An ore having the composition of the one here in question would, at this present time, be worth from $2.92 to $3.65 per ounce, troy, in the English market. The osmiridium, as occurring in it, was not in a form suitable for the purposes above specified.

Platinum, economic uses of, cont.

Osmiridium, economic uses of.

Native Arsenic.

A specimen of what proved to be native arsenic, weighing about half a pound, was forwarded to the Survey in August last by Mr. W. F. McCulloch, of Victoria, who informed me that it was stated to have been found on the western bank of the Fraser River, a short distance above Lillooet, British Columbia.

Native arsenic from the Fraser River, British Columbia.

Cinnabar.

Cinnabar.

In his report on the mines and minerals of British Columbia, Report of Progress 1876–77, pp. 103–149, Dr. G. M. Dawson states that it appears certain that small quantities of cinnabar have been obtained in gold-washing on the Fraser River, near Boston Bar; that in the autumn of 1876 he received a small but well authenticated specimen of rich cinnabar ore from Mr. Tiedemann, found by that gentleman in the vicinity of the located line of railway on the Homathco River; and further, that he has seen a rich specimen of cinnabar and native mercury said to have been found on the west side of the Fraser River, near Clinton. In August last, Mr. A. J. Hill, C.E., of New Westminster, sent to the Survey a rich specimen of cinnabar reported to have been found (loose) in the immediate vicinity of that place.

Localities of occurrence of, in British Columbia.

The present specimen was collected, during the past season, by Mr. R. G. McConnell. It came from the Ebenezer Mine, Hector (Kicking Horse) Pass, two and a-half miles east of Golden City, Rocky Mountains, British Columbia, and consisted of a white, fine crystalline-granular limestone, through which was disseminated small quantities of a bright-red colored cinnabar and minute crystals of iron pyrites.

A portion of the specimen was submitted to assay; the results showed it to contain traces of gold, but no silver.

APATITE.

Apatite from Eabamet Lake, Albany River, Severn District.

The following specimen was collected (1886) by Dr. R. Bell, on the north side of Eabamet Lake, Albany River, Severn District. It consisted of small hexagonal prisms of from five to seven millimetres in diameter, of bluish-green to sea-green apatite, disseminated through a light colored granite, which is stated by Dr. Bell to constitute veins cutting the micaceous gneiss at the locality in question.

COOKEITE.

Cookeite from Big Bend, Columbia River, British Columbia.

A micaceous mineral, which may prove to be identical with Cookeite, was found sparsely disseminated, in the form of minute greyish-white pearly scales, through a specimen of galena from the Little Bunting lead, Big Bend, Columbia River, British Columbia (*vide* Gold and Silver Assays, Assay No. 101).

Mr. E. B. Kenrick, who first detected its presence, found that, when heated before the blow-pipe, it exfoliated like vermiculite and colored the flame intense carmine-red; in the closed tube it gave off water, the tube becoming slightly etched; it was slightly fusible, and gave with cobalt solution a blue color; with salt of phosphorus, a skeleton of silica. Insufficiency of material precluded the possibility of a closer examination.

URANINITE, CORACITE AND URACONITE.

Uraninite from Villeneuve, Ottawa county, Province of Quebec.

Amongst the specimens received in October last for identification was one which on examination proved to be uraninite. It was obtained at the so-called Villeneuve mica mine, which is situate on the thirtieth lot of the first range of Villeneuve, Ottawa county, Province of Quebec. The vein in which the mica occurs has been described as a coarse pegmatite, cutting a greyish garnetiferous gneiss. It is composed of quartz, muscovite, microcline and albite, with occasionally black tourmaline and garnet. The specimen, to which was attached a little muscovite, weighed about one pound, and consisted, apparently, of the greater portion of what had been a lenticular nodule. Structure, massive. Specific gravity (15·5° C.), as determined by Mr. Kenrick, 9·055. It had on one portion of its surface a moderately thick incrustation, the prevailing color of which was yellowish-red to scarlet-red, a small portion of the same had, however, a pure sulphur yellow color. This material, which is most probably gummite, was found by Mr. Kenrick to have a specific gravity (15·5° C.) of 3·78.

Coracite from Mamainse, Lake Superior, Ontario.

Previous to the finding of this specimen, pitch-blende was not known to occur in Canada. Coracite, a closely related mineral, has been met with at Mamainse, east side of Lake Superior, where it is

said to form a vein about two inches in width, at the junction of the trap and syenite (Geology of Canada, 1863). It was first described, and named, in 1847 by Dr. J. L. Leconte, subsequently analysed by Prof. J. D. Whitney in 1849, and again by Dr. F. A. Genth in 1857. Coracite from Mamainse, Lake Superior, Ontario, cont.

Uraconite, another uranium mineral, is mentioned by Dr. T. S. Hunt (Geology of Canada, 1863) as occurring in the form of a sulphur-yellow crystalline crust, lining fissures in the magnetite of the Seymour ore-bed, lot eleven, range five of Madoc, Hastings county, Ontario; and more recently Prof. E. J. Chapman has noticed the occurrence of the same mineral with magnetite on lot twenty, range one of Snowdon, Peterborough county, also in the Province of Ontario. Uraconite from Madoc, Hastings county, Ontario. Uraconite from Snowdon, Peterborough county, Ontario.

Uranium is not a very abundant element. The principal ore is uraninite, which consists of more or less impure uranoso-uranic oxide. It is of economic importance, being employed in chemical operations, for painting on porcelain, and glass-staining. Uranium, economic uses of.

MONAZITE.

This was received almost simultaneously with the last mentioned, and was also obtained at the Villeneuve mica mine, above referred to. It was in the form of a nodular mass, to which was attached a little muscovite and felspar, weighing twelve and a quarter pounds. Monazite from Villeneuve, Ottawa county, Province of Quebec.

Structure, compact; color, reddish-brown; lustre, resinous; specific gravity, 5·138 (15·5° C.) Its blow-pipe characters and general composition, as determined by a rough quantitative analysis, conducted by by E. B. Kenrick, agree with those of monazite. This specimen will be submitted to analysis, and its exact composition determined.

This is the first time that this interesting mineral has been met with in Canada.

SMALTITE.

This mineral was observed, by Mr. E. B. Kenrick, in the form of minute crystals with well-marked octahedral cleavage, in association with chalcopyrite from the township of McKim, District of Nipissing, Ontario. Smaltite from McKim, District of Nipissing, Ontario.

So far as I am aware, this is the first notice of the occurrence of this mineral in Canada.

NATURAL WATERS.

Natural waters.

1.—*Saline Water.*—The spring from which this water was taken was struck at a depth of one hundred and fifty feet in sinking for water at a point three miles below the village of L'Assomption, and five hundred yards on the north side of the L'Assomption River, L'Assomption county, Province of Quebec. Water from spring near L'Assomption, Province of Quebec.

Water from spring near L'Assomption, Province of Quebec, cont.

The sample examined, which was received from Dr. Forest, contained a small quantity of chocolate-brown colored suspended matter. This was removed by filtration. The filtered water had a brownish-yellow tinge; was inodorous; had a saline taste exhibited a distinct alkaline reaction with reddened litmus paper, and a slightly alkaline reaction with turmeric paper; when boiled, deposited a copious precipitate consisting, for the most part, of carbonates of lime and magnesia. Total dissolved saline matter, dried at 180° C., equalled 16·85 parts in 1000. The water contained: acids—carbonic acid, chlorine; bases—potassa, soda, lime, magnesia, a little iron, some manganese, and further—baryta, strontia and lithia, which were detached by means of the spectroscope. No other constituents were sought for.

This water belongs to the third class of Dr. T. Sterry Hunt's classification of mineral waters. This class includes such saline waters as contain, besides chloride of sodium, with a little chloride of potassium, a portion of carbonate of soda, with bicarbonates of lime and magnesia. Small amounts of baryta, strontia, iron, manganese, and of boracic and phosphoric acids, are often, and alumina and silica, generally, present in these waters, and bromides and iodides are very rarely wanting.

Water from spring at Port Elgin, Bruce county, Ontario

2.—From a spring at Port Elgin, Bruce county, Ontario. Collected by Mr. A. S. Cochrane.

The water contained a small amount of suspended matter, which consisted almost entirely of ferric hydrate. The filtered water was colorless and odorless, had a specific gravity, at 15·5° C., of 1002·69, and contained 2·925 parts of dissolved saline matter. dried at 180° C., in 1000 parts, by weight, of the water.

A qualitative analysis, by Mr. E. B. Kenrick, showed in to contain:—

Potassa	trace.
Soda	fairly large quantity.
Lithia	trace.
Strontia	small quantity.
Lime	very large quantity.
Magnesia	large quantity.
Ferrous oxide	trace.
Sulphuric acid	very large quantity.
Phosphoric acid	trace.
Silica	trace.
Chlorine	very large quantity.

Boiling produced but a comparatively small precipitate, which consisted for the most part of lime, with a very small quantity of

magnesia and a trace of iron, also some sulphuric acid and a trace of phosphoric acid.

3.—From Dougherty's so-called carbonic acid spring, mountains between Clinton and Carguiles, British Columbia. Collected by Mr. A. Bowman.

Water from spring between Clinton and Carguiles, British Columbia.

The water contained some suspended matter, consisting chiefly of carbonate of lime, with some argillaceous and organic matter, and a little ferric hydrate. This having been removed by filtration, the water was found to have a specific gravity, at 15·5° C., of 1000 90, and to contain 1·442 parts of dissolved solid matter, dried at 180° C., in 1000 parts, by weight, of the water.

A qualitative analysis afforded Mr. E. B. Kenrick the following results:—

Potassa	trace.
Soda	small quantity.
Lime	large quantity.
Strontia	trace.
Magnesia	large quantity.
Alumina	very small quantity.
Sulphuric acid	fairly large quantity.
Carbonic acid	large quantity.
Silica	small quantity.
Chlorine	small quantity.
Organic matter	small quantity.

Boiling produced a copious precipitate, which contained a large quantity of lime, a fairly large quantity of magnesia, a very small quantity of alumina, and a trace of strontia; a large quantity of carbonic acid and a small quantity of sulphuric acid.

4.—From so-called sulphur spring on Sulphur Coulée, near its junction with the Pembina River. Procured by Dr. G. M. Dawson, who informs me that it issues from shales of Cretaceous age. The springs represented by this, and the following water, are referred to by him in his Report on the Geology and Resources of the 49th Parallel, 1875, p. 146.

Water from spring on Sulphur Coulée, Pembina River, Manitoba.

This water contained a certain amount of suspended and sedimentary matter, consisting of carbonate of lime, with traces of magnesia and ferric hydrate, some argillaceous and organic matter, and a little sand. This was removed by filtration. The filtered water had a specific gravity, at 15·5° C., of 1000·42, and contained 0·862 parts dissolved saline matter, dried at 180° C., in 1000 parts, by weight, of the water.

Water from spring on Sulphur Coulée, Pembina River, Manitoba, cont.

Agreeably with the results of a qualitative analysis, made by Mr. E. B. Kenrick, it contained :—

Potassa	small quantity.
Soda	rather large quantity.
Lithia	very small quantity.
Lime	large quantity.
Magnesia	large quantity.
Sulphuric acid	large quantity.
Carbonic acid	large quantity.
Chlorine	large quantity.
Organic matter	small quantity.

Boiling produced only a very slight precipitate, which consisted mainly of carbonates of lime and magnesia, together with a little sulphate of lime.

Water from spring at foot-hills of Western Butte, North-West Territory.

5.—From spring at foot-hills of Western Butte, Sweet Grass Hills, District of Alberta, North-West Territory. Procured by Dr. G. M. Dawson, who informs me that it rises from dark shales of Cretaceous age.

The water, which as it issues from the spring is charged with sulphuretted hydrogen, still contained a large quantity of that gas. It contained some suspended and sedimentary matter, consisting of carbonate of lime, a little iron, and separated sulphur, together with argillaceous and organic matter, and some sand. The filtered water had a specific gravity, at 15·5° C., of 1001·36. Total dissolved saline matter, dried at 180° C., equalled 0·857 parts in 1000.

Mr. E. B. Kenrick made a qualitative examination of the water, and found it to contain :—

Potassa	trace.
Soda	small quantity.
Lithia	very distinct trace.
Lime	fairly large quantity.
Magnesia	very large quantity.
Alumina	very small quantity.
Ferrous oxide	trace.
Sulphuric acid	small quantity.
Carbonic acid	very large quantity.
Chlorine	small quantity.
Hydrosulphuric acid	large quantity.
Organic matter	small quantity.

Boiling produced a very copious precipitate, containing a somewhat large quantity of lime, a very large quantity of magnesia, a little alumina and a trace of iron, together with a very large quantity of carbonic acid and a trace of sulphuric acid.

6.—Water from hot spring one and a-half miles north of the north end of Upper Columbia Lake, Columbia Valley, British Columbia. Collected by Dr. G. M. Dawson. Water from hot spring near Upper Columbia Lake, British Columbia.

This gentleman informs me that "the spring is about half a mile east of the trail, on the slope of a hill, and issues in several places from the summit and sides of a rounded, calcareous knoll formed by its deposit. The main efflux, at the summit of the knoll, has produced a raised basin, which within measures about eight by four feet, and is two feet deep, forming an admirable natural bath. The discharge at this place is probably not less than twenty gallons per minute, and the temperature of the water at this, the hottest, point was found to be 112° F. There is no discharge of gas, but the water has a slight styptic saline taste."

This water was found to have a specific gravity, at 15·5° C., of 1001·48, and to contain 2·177 parts of dissolved saline matter, dried at 180° C., in 1000 parts, by weight, of the water.

A qualitative analysis, conducted by Mr. E. B. Kenrick, showed it to contain:—

Potassa	trace.
Soda	rather small quantity.
Lithia	trace.
Baryta	trace.
Strontia	very small quantity.
Lime	very large quantity.
Magnesia	large quantity.
Ferrous oxide	trace.
Sulphuric acid	very large quantity.
Carbonic acid	large quantity.
Silica	trace.
Chlorine	fairly large quantity.
Organic matter	small quantity.

On boiling it deposited a very copious precipitate, which on examination was found to contain a very large quantity of lime, a small quantity of magnesia, a very small quantity of strontia, and traces of baryta and iron, together with large quantities of sulphuric and carbonic acids.

This water may not improbably be found to possess therapeutic properties, and hence be worthy of notice as a remedial agent.

IRON ORES.

Iron Ores.

1.—Magnetic iron-ore from the Belvedere iron mine, lot eight of the ninth range of Ascot, county of Sherbrooke, Province of Quebec. Collected by Mr. R. W. Ells. Examined for Mr. E. Clark. Magnetite from the Belvedere mine, Sherbrooke county, Province of Quebec.

Magnetite from the Belvedere mine, Sherbrooke county, Province of Quebec, cont.

A fine granular ore of a purplish, dark-grey color. The magnetite, which is very fine-crystalline, is very evenly disseminated through the gangue. It is said to form a very extensive deposit. A partial analysis, by Mr. F. D. Adams, gave (after drying at 100° C. —Hygroscopic water = 0·056 per cent.) the following results:—

Ferric oxide	26·669
Ferrous oxide	12·502
Titanium dioxide	none.
Insoluble matter	45·794
Metallic iron, total amount of	28·392

In view of the small percentage of iron, determinations of phosphoric acid and sulphur were not carried out.

Magnetite from the Leduc mine, Ottawa county, Province of Quebec.

2.—Magnetic iron-ore from the Leduc mine, lot twenty-three of the sixth range of Wakefield, county of Ottawa, Province of Quebec. Examined for Mr. J. Lambe.

Structure, compact: color, greyish-black: lustre, metallic: strongly magnetic. Determinations—by Mr. E. B. Kenrick—of the more important constituents gave (after drying at 100° C.—Hygroscopic water = 0·069 per cent.) the following results:—

Ferric oxide	64·593
Ferrous oxide	30·819
Titanium dioxide	trace.
Phosphoric acid	0·027
Sulphur	—
Insoluble matter	1·551
Metallic iron, total amount of	69·185
Phosphorus	0·012

Magnetite from St. Jerome, Terrebonne county, Province of Quebec.

3.—Magnetic iron-ore from about two and a-half miles south of the village of St. Jerome, on the west side of the North River, county of Terrebonne, Province of Quebec.

It was somewhat coarsely crystalline, and possessed an indistinct banded structure. It was found—by Mr. F. D. Adams—to contain (after drying at 100° C.—Hygroscopic water = 0·058 per cent.) as follows:—

Ferric oxide	59·059
Ferrous oxide	26·807
Titanium dioxide	none.
Phosphoric acid	0·015
Sulphur	0·001
Insoluble matter	9·897
Metallic iron, total amount of	62·191
Phosphorus	0·007
Sulphur	0·001

The proportions of ferric and ferrous oxide are very nearly those required by theory for magnetite, the ratio of ferrous to ferric oxide being 1 : 2·20 instead of 1 : 2·22.

4.—Magnetic iron-ore from the vicinity of Little Gull Lake, District of Thunder Bay, Lake Superior, Ontario. Received by Mr. E. D. Ingall from Mr. P. Laplante.

Magnetite from Little Gull Lake, District of Thunder Bay, Ontario.

Structure, compact; color, dark steel-grey. A partial analysis, by Mr. E. B. Kenrick, showed it to contain (after drying at 100° C.—Hygroscopic water = 0·195 per cent.) as follows:—

Ferric oxide	55·455
Ferrous oxide	18·272
Titanium dioxide	none.
Insoluble matter	23·450
Metallic iron, total amount of	53·030

5.—Magnetic iron-ore from the mining location of Mr. McLennan on Rainy Lake, near the mouth of the Seine River, Ontario. Collected by Mr. A. C. Lawson, who informs me that it occurs in green schists of presumed Huronian age.

Magnetite from Rainy Lake, Ontario.

Structure, compact; color, faint purplish greyish-black—many specimens exhibit a greenish tinge, due to the presence of a greenish chloritic mineral which is disseminated through this ore. Readily attracted by the magnet. Agreeably with the results of a partial analysis, conducted by Mr. E. B. Kenrick, it contained (after drying at 100 C.—Hygroscopic water = 0·060 per cent.) as follows:—

Ferric oxide	27·277
Ferrous oxide	32·089
Titanium dioxide	21·378
Insoluble matter	10·436
Metallic iron, total amount of	44·052

6.—Magnetic iron-ore from the Sooke iron mine, on the Strait of Juan de Fuca, Vancouver Island, British Columbia. The specimens in question were received from the Minister of Mines. The determinations of the iron were made by Mr. E. B. Kenrick.

Magnetite from Sooke iron mine, Vancouver Island, British Columbia.

I.—Consisted of an intimate mixture of a very fine crystalline magnetite and earthy hematite: it contained a somewhat large amount of iron-pyrites.

Metallic iron .... 58·49 per cent.

II.—A very fine crystalline magnetite.

Metallic iron .... 55·83 per cent.

Magnetite from Sooke iron mine, Vancouver Island, British Columbia, cont.

III.—A fine crystalline magnetite, through which was disseminated a somewhat large amount of iron-pyrites.

Metallic iron........................ 63·64 per cent.

IV.—A fine crystalline magnetite.

Metallic iron........................ 63·57 per cent.

V.—A very fine crystalline magnetite.

Metallic iron........................ 48·94 per cent.

VI.—Magnetite, together with a little copper-pyrites, in a gangue consisting almost exclusively of actinolite.

Metallic iron........................ 28·28 per cent.

VII.—A fine crystalline magnetite, through which was disseminated a little iron-pyrites.

Metallic iron........................ 59·06 per cent.

VIII.—A very fine crystalline magnetite.

Metallic iron........................ 52·03 per cent.

Hematite from South Crosby, Leeds county, Ontario.

7.—Red hematite from the nineteenth lot of the ninth range of South Crosby, about one mile from Chaffey locks, Rideau Canal, Leeds county, Ontario. Examined for Mr. N. Brown. The specimen examined had a somewhat large amount of calcite disseminated through it. Mr. E. B. Kenrick found it to contain:—

Metallic iron........................ 28·14 per cent.

Magnetite from Stephen C. E. Smith mine, Sherbrooke county, Province of Quebec.

8.—Magnetic iron-ore from the Stephen E. Smith mine, lot twenty-one of the sixth range of Ascot, Sherbrooke county, Province of Quebec. Collected by Mr. R. W. Ells, who informs me that it constitutes an extensive deposit.

Massive, very fine crystalline; color, greyish-black with a greenish tinge. Mr. E. B. Kenrick has made a partial analysis of this ore, determining the more important constituents, and found it to contain (after drying at 100° C.—Hygroscopic water = 0·216 per cent.) as follows:—

Ferric oxide	49·776
Ferrous oxide	24·725
Titanium dioxide	none.
Phosphoric acid	1·512
Sulphur	·024
Insoluble matter	11·235
Metallic iron, total amount of	54·074
Phosphorus	·660
Sulphur	·024

Hematite and limonite from Big Island, Lake Winnipeg, Manitoba.

9.—Hematites and limonites from Big Island, Lake Winnipeg, Manitoba. Received from Mr. F. Proudfoot.

	I.	II.	III.	IV.	V.
Ferric oxide	77·13	50·37	73·64	39·34	17·19
Water { hygroscopic	·16	·91	4·74	1·20	·36
Water { combined	—	—	13·57	6·45	undet.
Insoluble matter	3·90	14·80	2·23	48·12	77·03
Metallic iron	53·99	35·26	51·55	27·54	12·03

I.—Hematite, botryoidal: gangue, calcite with a little quartz.
II.—Hematite, ochreous: gangue, calcareous and siliceous.
III.—Limonite.
IV.—Limonite, through which was disseminated rounded grains of quartz.
V.—Quart, with limonite and a little hematite.

COPPER ORES.

Copper Ores.

Cupiferous rock from Sooke, Vancouver Island, British Columbia.

1.—From the Sooke copper-mine, on the Strait of Juan de Fuca, Vancouver Island, British Columbia. Received from the Minister of Mines.

The specimen examined consisted of a dark-green chloritic rock, through which was disseminated very thin scales of native copper. Agreeably with the results of a determination made by Mr. E. B. Kenrick, it contained:—

Copper .... 1·02 per cent.

Copper-pyrites from McKim, District of Nipissing, Ontario.

2.—From the township of McKim, District of Nipissing, Ontario.

A specimen of what, at a first glance, appeared to be a very pure copper-pyrites—but which on close examination was found to contain a very appreciable amount of rock-matter and magnetic-pyrites disseminated through it—from this locality was examined by Mr. E. B. Kenrick and found to contain:—

Copper .... 24·62 per cent.

MANGANESE ORES.

Manganese Ores.

Bog manganese from Lewis Bay, Cape Breton county, Nova Scotia.

I.—Bog manganese from the head of Lewis Bay, Grand Mira, Cape Breton county, Nova Scotia. Examined for Dr. M. A. McDonald.

The sample was in the form of porous friable lumps, varying in color from dark-brown to brownish-black. A partial analysis of the same—after drying at 100° C.—Loss by moisture = 22·22 per cent.—afforded Mr. E. B. Kenrick the following results:—

Manganese dioxide—available .... 44·99 per cent.
Insoluble matter .... 12·25 "

Gold and Silver Assays.

GOLD AND SILVER ASSAYS.

These were, with one exception, all conducted by Mr. E. B. Kenrick.

LABRADOR.

Labrador.

1.—From first cove south side of Nachvak Inlet. Collected by Dr. R. Bell.

A white translucent quartz, in parts stained with hydrated peroxide of iron, with here and there small quantities of a bright green chloritic mineral. The sample, which consisted of five fragments, weighed two pounds six ounces.

It contained neither gold nor silver.

2.—From the south side of Nachvak Inlet, opposite Skynner's Cove. Collected by Dr. R. Bell.

A white sub-translucent quartz, seamed and, in parts, stained with hydrated peroxide of iron. Weight of specimen, three and a-half pounds. It was found to contain :—

Gold........ trace.
Silver....... 0·041 of an ounce to the ton of 2,000 lbs.

PROVINCE OF NOVA SCOTIA.

Province of Nova Scotia.

3.—From Pleasant Bay, Inverness county. Examined for Mr. J. D. Ferguson.

A dark-grey limestone, carrying a little galena. Weight of specimen, five pounds two and a-half ounces.

It contained neither gold nor silver.

4.—This and the five following specimens are from exposures on the Sissiboo River, about seven miles above Weymouth, Digby county. They were examined for Mr. J. Robertson.

From old camp.—A faintly pinkish-white sub-translucent quartz, associated with a small quantity of a dark bluish-grey shale. Some fragments were, in parts, coated with hydrated peroxide of iron, and also contained cavities holding the same material. Weight of specimen, six pounds one ounce.

It contained neither gold nor silver.

5.—From foot of new road.—A milky white quartz, associated with a dark bluish-grey shale. Some of the fragments contained a trifling amount of iron-pyrites, and were more or less stained with hydrated peroxide of iron. Weight of specimen, nearly four pounds.

It contained neither gold nor silver.

6.—From foot of Schooner passage.—A faintly greyish-white quartz, in association with a dark bluish-grey shale. It contained a small quantity of iron-pyrites, and was, in parts, coated with hydrated peroxide of iron. Weight of specimen, five and three quarter pounds. Gold and Silver Assays, cont. Province of Nova Scotia, cont.

It contained neither gold nor silver.

7.—From head of Schooner passage.—A white sub-translucent quartz, associated with a small amount of a dark bluish-grey shale. It contained a trifling amount of iron-pyrites, and was in parts stained with hydrated peroxide of iron. Weight of specimen, six and a-quarter pounds.

It contained neither gold nor silver.

8.—From Wagner's Rips.—An association of white and grey quartz, and dark bluish-grey shale. It contained a small quantity of iron-pyrites, numerous cavities lined with hydrated peroxide of iron, and was also, in parts, coated with the latter material. Weight of specimen, six and three-quarter pounds.

It contained neither gold nor silver.

9.—From Gates No. 4.—A white quartz, in association with a dark bluish-grey shale. It contained a little iron-pyrites, and was more or less coated with hydrated peroxide of iron. Weight of specimen, twelve and a-half pounds.

It contained neither gold nor silver.

Province of Quebec.

10.—From the first lot of the tenth range of South Metgermette, county of Beauce. Province of Quebec.

It consisted of a white quartz, in parts stained with hydrated peroxide of iron, associated with a small quantity of chloritic matter, and containing, here and there, a few specks of iron-pyrites. Weight of specimen, seven ounces.

It contained neither gold nor silver.

11.—From the township of Risborough, county of Beauce.

An association of galena, copper-pyrites, iron-pyrites, and small quantities of tetrahedrite and magnetic-pyrites, in a gangue of white translucent quartz. Weight of specimen, one pound eight ounces. It contained:—

Gold........... traces.
Silver.......... 43·633 ounces to the ton of 2,000 lbs.

Gold and Silver Assays, cont.

Province of Quebec, cont.

12.—From the tenth lot of the tenth range of Wakefield, county of Ottawa. Examined for Mr. W. A. Allan.

A white translucent quartz in association with a little felspar. It was found to contain:—

Gold	minute trace.
Silver	none.

13.—From veins traversing the Gaspé limestone at Indian Cove, two and a-half miles from Ship Head, Gaspé Bay, Gaspé county.

The occurrence of galena at this place has been referred to in the Geology of Canada, 1863, pp. 400, 516 and 691, and more recently in the Report of Progress for 1880–81–82, p. 15 DD. The specimen, which weighed four and a-half ounces, was collected by Mr. A. P. Low. It consisted of a somewhat coarse crystalline galena, in association with a very trifling amount of calcite. Assays gave:—

Gold	none.
Silver	0·146 of an ounce to the ton of 2,000 lbs.

NORTH-EAST TERRITORY.

14.—From veins at Stupart's Bay, south side of Hudson's Strait. Collected by Dr. R. Bell.

A white, sub-translucent to translucent quartz carrying iron-pyrites; some of the fragments were much stained with hydrated peroxide of iron. Weight of specimen, three pounds nine ounces. Assags gave:—

Gold	trace.
Silver	none.

15.—From Port Burwell, Cape Chudleigh, Hudson's Strait. Collected by Dr. R. Bell.

A greyish-white sub-translucent quartz, with which was associated a little barite, carrying small quantities of pyrite; some of the fragments were stained and coated with hydrated peroxide of iron. Weight of specimen, one pound fifteen ounces. It was found to contain:—

Gold	trace.
Silver	none.

HUDSON'S BAY.

Hudson's Bay.

16.—Veinstone from small veins cutting diorite, Ottawa Islet. Collected by Dr. R. Bell.

An intimate association of calcite and plagioclase, containing, here and there, a few specks of iron-pyrites. Weight of specimen, one pound thirteen ounces. Assays showed it to contain:— Gold and Silver Assays, cont.

Gold....... distinct trace.
Silver...... 0·069 of an ounce to the ton of 2,000 lbs.

PROVINCE OF ONTARIO.

Of the following specimens, Nos. 17 *to* 50, *inclusive, were collected by Mr. E. D. Ingall.* Province of Ontario.

17.—Wall rock from a vein at Little Trout Bay.

A dark-greyish, highly siliceous rock, through which was disseminated a small quantity of iron-pyrites. Weight of specimen, seven and a-half ounces.

It contained neither gold nor silver.

18.—Veinstone from foregoing vein.

Barite associated with a little quartz; it was, in parts, slightly stained with hydrated peroxide of iron. Weight of specimen, six ounces.

It contained neither gold nor silver.

19.—From a vein at the eastern end of Jarvis Island, north-west shore of Lake Superior, between Thunder Bay and Pigeon River.

It consisted of barite. Weight of specimen, seven and a-half ounces.

It contained neither gold nor silver.

20.—From a vein at the western end of Jarvis Island. A selected specimen.

An association of calcite, barite and iron-pyrites. Weight of specimen, ten ounces.

It contained neither gold nor silver.

21.—From a vein on Prince's location. A selected specimen.

An association of calcite and quartz, carrying a little galena. Weight of specimen, one pound eleven ounces.

It contained neither gold nor silver.

22.—From a vein east of the one last mentioned.

A coarse crystalline calcite associated with a little quartz; it contained, here and there, a few specks of bornite and chalcocite. Weight of specimen, ten ounces.

It contained neither gold nor silver.

Gold and Silver Assays, cont.

Province of Ontario, cont.

23.—From a vein at the northern end of Spar Island, Thunder Bay, Lake Superior.

An association of calcite and barite, carrying small quantities of copper-pyrites, copper-glance, bornite and zinc-blende. Weight of specimen, four and a-half ounces. It contained:—

Gold .... distinct trrces.
Silver........... 2·158 ounces to the ton of 2,000 lbs.

24.—From a vein about the middle of the south shore of Spar Island, Thunder Bay, Lake Superior.

An association of a coarse crystalline calcite and barite; it contained a few specks of galena. Weight of specimen, twelve and a-half ounces.

It contained neither gold gor silver.

25.—This, and the three following, are selected specimens from a vein at the eastern end of Pie Island, Thunder Bay, Lake Superior.

A light greenish-grey colored, highly siliceous rock, carrying a little galena. Weight of specimen, one pound eleven and three-quarter ounces. Assays showed it to contain:—

Gold........ none.
Silver....... 0·175 of an ounce to the ton of 2,000 lbs.

26.—A dark-grey shale, associated with a little colorless crystalline quartz, carrying a small quantity of zinc-blende and a trifling amount of galena. Weight of specimen, nine ounces.

It contained neither gold nor silver.

27.—Iron-pyrites associated with a little dark-grey shale. Weight of specimen, four and a-quarter ounces.

It contained neither gold nor silver.

28.—A dark, slightly greenish-grey shale, carrying a trifling amount of galena. Weight of specimen, eight and a-quarter ounces.

It contained neither gold nor silver.

29.—From a vein about half a mile south-east of that from which the four preceding specimens were taken.

A dark-grey shale, associated with a little quartz, carrying a little galena and a very trifling amount of zinc-blende. Weight of specimen, three and a-quarter ounces. It contained:—

Gold........ none.
Silver....... 0·467 of an ounce to the ton of 2,000 lbs.

30.—From a vein on the south shore of Pie Island, Thunder Bay, Lake Superior. Gold and Silver Assays, cont.

An association of calcite and quartz, carrying a little galena and a very trifling amount of iron-pyrites. Weight of specimen, five and a-quarter ounces. Province of Ontario, cont.

It contained neither gold nor silver.

31.—From a vein on the south shore of Thompson's Island, Thunder Bay, Lake Superior.

Iron-pyrites associated with a small quantity of coarse crystalline calcite. Weight of specimen, four ounces.

It contained neither gold nor silver.

32.—This, and the three following, are selected specimens from a vein on McKellar's Island, Thunder Bay, Lake Superior.

An association of barite and calcite, through which was disseminated a little iron-pyrites and a few specks of galena and zinc-blende. Weight of specimen, fifteen and a-quarter ounces. It was found to contain :—

Gold .... none.
Silver ...... 0·233 of an ounce to the ton of 2,000 lbs.

33.—Barite, through which was disseminated a few specks of iron-pyrites and zinc-blende, with, here and there, a little hydrated peroxide of iron. Weight of specimen, thirteen and a-quarter ounces. Assays gave :—

Gold .... none.
Silver ...... 0·233 of an ounce to the ton of 2,000 lbs.

34.—An association of quartz and calcite, with, here and there, a few specks of zinc-blende and galena. Weight of specimen, nine and a-half ounces.

It contained neither gold nor silver.

35.—Barite, with which was associated a trifling amount of iron-pyrites. Weight of specimen, seven ounces. Assays showed it to contain :—

Gold .... none.
Silver ...... 0·058 of an ounce to the ton of 2,000 lbs.

36.—From a vein near Little Gull Lake. A selected specimen.

A coarse crystalline calcite associated with a little quartz and dark-green chlorite; it contained a trifling amount of zinc-blende

Gold and Silver Assays, cont.

Province of Ontario, cont.

and iron-pyrites. Weight of specimen, ten and a-half ounces. It was found to contain:—

Gold .... none.
Silver ...... 0·058 of an ounce to the ton of 2,000 lbs.

37.—From the same vein as the last. Taken from bottom of shaft.

A coarse crystalline calcite in association with a small quantity of quartz and fluorite, with, here and there, a little zinc-blende and a few specks of galena. Weight of specimen, one pound.

It contained neither gold nor silver.

38.—From a vein near to, running parallel with, and north of that from which the two preceding specimens were taken. A selected specimen.

An association of a dark-grey shale and amethystine quartz, carrying a little iron-pyrites. Weight of specimen, seven and a-quarter ounces.

It contained neither gold nor silver.

39.—From a vein near Whitefish River, north of Whitefish Lake.

Calcite, through which was disseminated a little zinc-blende. Weight of specimen, six ounces.

It contained neither gold nor silver.

40.—From a vein on location 96 T., Rabbit Mountain district.

Calcite, with which was associated a little fluorite, also small quantities of zinc-blende, galena, iron-pyrites, copper-pyrites, copper-glance and bornite, with, here and there, a little green carbonate of copper and hydrated peroxide of iron. Weight of specimen, one pound one ounce. It contained:—

Gold .... trace.
Silver ...... 0·175 of an ounce to the ton of 2,000 lbs.

41.—From a vein on location R. 95, Silver Mountain district.

Barite associated with a little quartz and fluorite. It contained, here and there, a trifling amount of zinc-blende and a few specks of silver-glance and native silver. Weight of specimen, one pound. It was found to contain:—

Gold........... none.
Silver.......... 14·292 ounces to the ton of 2,000 lbs.

42.—From a vein on location R. 70, Silver Mountain district.

An association of calcite, quartz and fluorite; it contained a few

specks of iron-pyrites, and was, in parts, coated with hydrated peroxide of iron. Weight of specimen, one pound two and a-half ounces. Assays gave:— Gold and Silver Assays, cont. Province of Ontario, cont.

Gold .... distinct traces.
Silver ...... 0·525 of an ounce to the ton of 2,000 lbs.

43.—From a vein on Whitefish River, location R. 135. A selected specimen.

An association of calcite, quartz and fluorite, carrying small quantities of zinc-blende, galena, and iron-pyrites. Weight of specimen, one pound.

It contained neither gold nor silver.

44.—From a vein on location R. 79, Silver Mountain district. A selected specimen.

Quartz, associated with a small quantity of a dark-grey shale; it contained a little galena, and was in parts slightly stained with hydrated peroxide of iron. Weight of specimen, five and a-half ounces.

It contained neither gold nor silver.

45.—From a vein on location R. 115, Silver Mountain district. A selected specimen from north vein.

An association of calcite, fluorite, and quartz, through which was disseminated a small quantity of zinc-blende. Weight of specimen, six and three-quarter ounces.

It contained neither gold nor silver.

46.—From a vein south of that last mentioned. A selected specimen.

A greyish-white quartz, in parts coated with hydrated peroxide of iron. Weight of specimen, thirteen and three-quarter ounces.

It contained neither gold nor silver.

47.—From a vein on location R. 111, Silver Mountain district. A selected specimen.

A greyish-white to white crystalline, translucent quartz, with a little iron-pyrites and galena. Weight of specimen, six and three-quarter ounces.

It contained neither gold nor silver.

48.—From a vein on location R. 57, Silver Mountain district. Sample from main branch in shaft, at a depth of about eighteen feet.

An association of barite, coarse crystalline calcite, fluorite, and

Gold and Silver Assays, cont.

Province of Ontario, cont.

a dark-grey shale, carrying a little iron-pyrites and zinc-blende, also some silver-glance and native silver. Weight of specimen, one pound ten ounces. Assays showed it to contain:—

Gold.......... none.
Silver......... 127·342 ounces to the ton of 2,000 lbs.

49.—From the same vein as that whence last mentioned specimen was taken. From side branches, south side of shaft, at a depth of about eighteen feet.

An association of quartz, calcite, barite, and fluorite. with a little iron-pyrites and zinc-blende, and a few specks of galena. Weight of specimen, thirteen ounces. It was found to contain:—

Gold .... trace.
Silver ...... 0·758 of an ounce to the ton of 2,000 lbs.

50.—From a vein on location R. 98, Silver Mountain district.

An association of quartz, calcite, fluorite, and a dark-grey shale, with, here and there, a few specks of galena. Weight of specimen, one pound two and a-half ounces.

It contained neither gold nor silver.

51.—From the so-called "Silver Fall's Mine," Silver Mountain district. Examined for Mr. A. Peroncelle.

The sample, which was stated to consist of material taken from various parts of the working, weighed ten pounds six ounces.

It contained neither gold nor silver.

52.—From Slate River, south of Rabbit Mountain. Examined for Mr. Watts.

A coarsely crystalline galena in a highly siliceous gangue; it was in parts coated with a little hydrated peroxide of iron. Weight of specimen, half an ounce.

It contained neither gold nor silver.

53.—From Sturgeon River (branch of), due north of the township of Badgerow, District of Nipissing.

It consisted of an association of a somewhat fine crystalline galena and copper-pyrites, with a white translucent quartz. The metallic sulphides constituted, approximately, ninety-three per cent., by weight, of the whole. Weight of specimen, six and three-quarter ounces. Assays showed it to contain:—

Gold.......... very distinct traces.
Silver......... 15·750 ounces to the ton of 2,000 lbs.

54.—From the fifteenth lot of the ninth range of Bagot, county of Renfrew. Examined for Mr. C. F. Gildersleeve. Gold and Silver Assays, cont. Province of Ontario, cont.

Iron-pyrites in a gangue consisting of white and red calcite, quartz, and mica. Weight of specimen, eight and three-quarter ounces.

It contained neither gold nor silver.

55.—From an opening about ten miles from Port Arthur, Thunder Bay, Lake Superior. Examined for T. S. Sproule, Esq., M.P.

It consisted of galena, associated with a little iron-pyrites, in a gangue of quartz. Weight of specimen, three ounces. It was found to contain :—

Gold	none.
Silver	1.458 ounces to the ton of 2,000 lbs.

DISTRICT OF KEEWATIN.

56.—From bay south of Cape Jones, north-west side of Hudson's Bay, nearly opposite Marble Island. Collected by Dr. R. Bell. District of Keewatin.

Massive, very fine crystalline iron-pyrites, through which was disseminated a light-greyish colored quartz, The latter constituted, approximately, twenty per cent., by weight, of the whole. Weight of specimen, six and a-half pounds. It contained :—

Gold	trace.
Silver	0·175 of an ounce to the ton of 2,000 lbs.

This specimen was also examined for copper—the results were negative.

57.—This and the following specimen is from the Minerva location, Minerva Island. The latter lies about nine miles south-west of Rat Portage, Lake of the Woods. They were examined for Mr. G. Denison Taylor.

This specimen was stated to have been taken from near the surface, and to constitute a continuous streak of from one to two inches in width near the northern wall.

A white translucent quartz, in association with a small quantity of a greenish-grey chloritic mineral ; the whole was more or less stained with hydrated peroxide of iron ; it contained a little iron-pyrites, a few specks of galena, and an occasional speck of gold. Weight of specimen, one and three-quarters ounces. Assays gave :—

Gold...........	7·696 ounces to the ton of 2,000 lbs.
Silver...........	0·671 of an ounce " "

Gold and Silver Assays, cont.

District of Keewatin, cont.

58.—The material constituting this sample consisted of specimens taken from:

a.—The shaft, at a depth of eight feet: consisting of a greyish-white translucent quartz, in association with a somewhat dark, greenish-grey chloritic rock, through which was disseminated a small quantity of iron-pyrites. Weight of specimen, two and a-half pounds.

b.—Shaft, hanging wall: an association of a greyish-white quartz and a dark, slightly greenish-grey chloritic rock, containing a small quantity of iron-pyrites. Weight of specimen, one pound two ounces.

c.—The shaft, at a depth of fifteen feet. This consisted of a greyish-white translucent quartz in association with a small quantity of a bright green chloritic mineral, and a trifling amount of calcite. It contained, in parts, a little iron-pyrites. Weight of specimen, one pound one ounce.

The whole was reduced to powder and intimately mixed, in order to obtain a fair average sample. It contained:—

Gold........	0·145 of an ounce to the ton of 2,000 lbs.
Silver	0·017 " " " "

59.—This, and the following specimen is from the Gold Hill Mine, Gold Lake, Big Stone Bay mining district, Lake of the Woods. They were collected by Mr. A. C. Lawson.

From Shaft No. 1.—A greyish-white to white, very fine crystalline quartzite, traversed by a few thin seams of a dark-green chloritic mineral. Weight of specimen, one pound ten ounces. It was found to contain:—

Gold	none.
Silver	0·117 of an ounce to the ton of 2,000 lbs.

60.—From Combination lead.—A white translucent quartz in association with a dark-green chloritic schist. Weight of specimen, four ounces. Assays gave:—

Gold	distinct traces.
Silver	0·233 of an ounce to the ton of 2,000 lbs.

61.—From the west side of Hudson's Bay, south of Chesterfield Inlet. Collected by Dr. R. Bell.

Iron-pyrites. Weight of specimen, eight ounces. Assays showed it to contain:—

Gold	trace.
Silver	0·233 of an ounce to the ton of 2,000 lbs.

North-West Territory.

62.—From township 26, range 15, west of 5th principal meridian—about ten miles south-west of Silver City. This and the two following specimens were examined for Mr. G. L. Lecomte. Gold and Silver Assays, cont. North-West Territory.

A milky-white quartz, containing cavities and fissures lined with hydrated peroxide of iron. Weight of specimen, one pound six ounces.

It contained neither gold nor silver.

63.—From the same locality as the preceding.

A greyish-white to white sub-translucent quartz. It was very much fissured, and contained numerous cavities; these were, in both instances, lined with hydrated peroxide of iron. Weight of specimen, two and three-quarter pounds.

It contained neither gold nor silver.

64.—From the south slope of the second mountain east of what is known as "Castle" Mountain, Rocky Mountains.

A fine to coarse crystalline calcite, containing a good deal of intermixed hydrated peroxide of iron, and a very appreciable amount of green carbonate of copper. Weight of specimen, one pound two and a-half ounces. Assays showed it to contain:—

Gold .... trace.
Silver ...... 0·700 of an ounce to the ton of 2,000 lbs.

65.—From a small island at the outlet of Burntwood Lake. Collected by Mr. A. S. Cochrane.

A white translucent quartz in association with a dark-grey shale; it contained. in parts, a little iron pyrites. Weight of specimen, five and a-quarter ounces. Assays gave:—

Gold .... trace.
Silver .... none.

66.—From the James Haney claim on Discovery Creek, north side, North Saskatchewan River, about sixty miles above Edmonton (section 35, township 50, range 4, west of 5th principal meridian), District of Alberta.

The sample consisted of a light, earthy, friable material, varying in color from pale yellowish to light reddish-brown, and a very fine-grained, hard, apparently baked, arenaceous clay shale of a pale dull yellow to light reddish-brown color. Agreeably with the results of an assay conducted by Mr. E. B. Kenrick,

It contained neither gold nor silver.

Gold and Silver Assays, cont.

North-West Territory, cont.

67.—The last mentioned was accompanied by another sample, consisting of a dark-colored scoriaceous mass, stated by the sender to consist of material similar to that just described, after it had been submitted to a smelting process, This was also assayed by Mr. E. B. Kenrick.

It contained neither gold nor silver.

In the course of a geological examination of the District of Alberta, during the past summer, Mr. J. B. Tyrrell visited the site of Mr. James Haney's claim, referred to in the last assay but one, and collected good representative specimens of the material, which, on his return, were placed in my hands for examination, and it is to these specimens that the following six assays have reference. Mr. Tyrrell informs me that what is known as Haney's first claim is in a mass of débris fallen from the burnt bed of lignite, while his second claim is in the burned out seam of lignite itself—the two claims being about a mile apart; further, that at about two miles from the site of these claims, and where the seam of lignite remains intact, the same has a thickness of twenty-six feet ten inches, including one foot ten inches of shaly partings.

A good deal of information in regard to the combustion of lignite beds will be found in Dr. G. M. Dawson's Report on the Geology and Resources of the Forty-ninth Parallel, p. 164.

68.—Ashes resulting from the combustion of the seam of lignite. Haney's second claim.

A more or less compacted, but friable, material, varying in color from pale yellowish to light reddish-brown. It was found to contain:—

Gold	trace.
Silver	none.

69.—Shale overlying the seam of lignite. Haney's second claim.

An arenaceous clay-shale, very fine-grained and of close texture; color, pale dull yellow to light, and occasionally dark reddish-brown. It bore evidences of having been submitted to a more or less intense heat. Assays gave:—

Gold	trace.
Silver	none.

70.—Material resulting from the combustion of the seam of lignite. Haney's first claim.

A clinkered mass, in parts scoriaceous, enclosing fragments of

burnt shale; the cementing material, which varied in color from bluish-ash to ash-grey and brownish-red, had a more or less vesicular structure; portions of the mass presented, externally, the appearance of a glassy slag. It contained:— Gold and Silver Assays, cont. North-West Territory, cont.

Gold	trace.
Silver	none.

71.—Material found lying on the surface of the ground at the foot of the slope in which the seam of lignite is exposed.

A clinkered semi-scoriaceous material; color, externally, for the most part, greyish-black with a slight brownish tinge; that of freshly fractured surface, ash-grey and brownish-red. Assays showed it to contain:—

Gold	trace.
Silver	none.

72—Boulder clay overlying Laramie sandstones, clays and lignite. From mouth of creek on which Haney's first claim is situated.

It contained neither gold nor silver.

73.—Shaly parting occurring, about eight feet from the top, in seam of lignite. Near Haney's first claim.

This material, which had a clove-brown to blackish-brown color, was also found to contain:—

Gold	traces.
Silver	none.

Province of British Columbia.

74.—This, and the two following specimens are from fifteen miles west of summit of Selkirk Range, and three miles north of the line of the Canadian Pacific Railway. Province of British Columbia.

A coarsely crystalline galena, in association with a trifling amount of calcite. Weight of specimen, nine ounces. Assays showed it to contain:—

Gold	traces.
Silver	74·521 ounces to the ton of 2,000 lbs.

75.—A white translucent quartz, in parts stained with hydrated peroxide of iron, carrying galena and a small quantity of zinc-blende. The metallic sulphides constituted, approximately, thirty-seven per cent., by weight, of the whole. Weight of specimen, eight and a-half ounces. Assays gave:—

Gold	none.
Silver	142·187 ounces to the ton of 2,000 lbs.

Gold and Silver Assays, cont.

Province of British Columbia, cont.

76.—A coarsely crystalline galena, almost entirely free from gangue. Weight of specimen, two and a-half ounces. It was found to contain:—

Gold........... none.
Silver.......... 66·354 ounces to the ton of 2,000 lbs.

77.—From about ten miles west of summit of Selkirk Range, and within one and a-half mile of the line of the Canadian Pacific Railway. Examined for Mr. W. A. Allan.

A coarsely crystalline galena in association with a little calcite and quartz. Weight of specimen, one pound nine ounces. It contained:—

Gold.......... minute trace.
Silver.......... 74·375 ounces to the ton of 2,000 lbs.

78.—This, and the three following specimens are from the Zerran mine, Scotch Creek, Shuswap Lake. The first three were examined for Mr. A. J. Hill, the fourth for Mr. B. Bailey.

Taken from the outcrop.—A moderately coarse crystalline galena, through which was disseminated a few particles of copper-pyrites, in association with small quantities of white translucent quartz and calcite. The metallic sulphides constituted, approximately, ninety per cent., by weight, of the whole. Weight of specimen, three ounces. Assays gave:—

Gold........... distinct traces.
Silver......... 11·667 ounces to the ton of 2,000 lbs.

79.—Taken ten feet in from mouth of tunnel.—A moderately fine crystalline galena, in a gangue of white translucent quartz. The galena constituted, approximately, forty-five per cent., by weight, of the whole. Weight of specimen, nearly two ounces. It was found to contain:—

Gold........... distinct traces.
Silver.......... 35·000 ounces to the ton of 2,000 lbs.

80.—Taken forty-eight feet in from mouth of tunnel.—A moderately coarse crystalline galena, in association with a white translucent quartz. The galena constituted, approximately, eighty per cent., by weight, of the whole. Weight of specimen, seven and a-half ounces. Assays showed it to contain:—

Gold........... distinct traces.
Silver.......... 46·667 ounces to the ton of 2,000 lbs.

81.—Taken fifty-two feet in from mouth of tunnel.—A moderately fine crystalline galena, through which was disseminated a trifling amount of iron-pyrites, in association with a white translucent quartz. The metallic sulphides constituted, approximately, seventy-two per cent., by weight, of the whole. Weight of specimen, nine and a-half ounces. Assays gave:— Gold and Silver Assays, cont. Province of British Columbia, cont.

Gold........... distinct traces.
Silver.......... 10·208 ounces to the ton of 2,000 lbs.

82.—This, and the following specimen are from Nicola Valley. They were examined for Mr. J. Crawford.

It consisted of an association of tetrahedrite, galena, iron-pyrites and zinc-blende, in a gangue of quartz. Weight of specimen, two and a-half ounces. It was found to contain:—

Gold........ 0·729 of an ounce to the ton of 2,000 lbs.
Silver....... 39·521 ounces " "

83.—A fine crystalline galena in association with a little iron-pyrites, in a gangue of quartz. Weight of specimen, two and three-quarter ounces. Assays gave:—

Gold........... distinct traces.
Silver.......... 20·927 ounces to the ton of 2,000 lbs.

84.—This, and the three following specimens are from the Selkirk Range, and within fifteen or twenty miles of Golden City, on the line of the Canadian Pacific Railway. They were examined for Mr. F. N. Gisborne.

A white translucent quartz, more or less coated with hydrated peroxide of iron. Weight of specimen, three and a-quarter ounces.

It contained neither gold nor silver.

85.—A white translucent quartz in association with a small quantity of a dark-grey hydrous mica. It was for the most part thickly coated with hydrated peroxide of iron. Weight of specimen, four and three-quarter ounces. Assays showed it to contain:—

Gold .... none.
Silver ...... 0·974 of an ounce to the ton of 2,000 lbs.

86.—The sample was made up of fragments of a white quartz and a dark grey limestone; the former were much honeycombed, the cavities holding hydrated peroxide of iron. Weight of specimen, two ounces.

It contained neither gold nor silver.

Gold and Silver Assays, cont.

Province of British Columbia, cont.

87.—A highly calcareous, and very ferruginous, readily friable sandstone, enclosing sharp angular fragments of a light grey, highly ferruginous limestone. Weight of specimen, eight ounces.

It contained neither gold nor silver.

88.—This, and the two following specimens are from exposures in the vicinity of the Big Bend, Columbia River. They were examined for Mr. R. A. McVitty.

A white translucent quartz, for the most part thickly coated with hydrated peroxide of iron. Weight of specimen, one and a-half ounces.

It contained neither gold nor silver.

89.—A moderately coarse crystalline galena, in a gangue of white translucent quartz; the latter was more or less stained with hydrated peroxide of iron. Weight of specimen, three and a-half ounces. Assays showed it to contain:—

Gold .... very distinct traces.
Silver.......... 43·750 ounces to the ton of 2,000 lbs.

90.—A white translucent quartz, in parts thickly coated with hydrated peroxide of iron. Weight of specimen, three and a-quarter ounces.

It contained neither gold nor silver.

91.—From the "Moberly lead," ten miles west of summit of Selkirk Range, and ten miles from the line of the Canadian Pacific Railway.

Galena, associated with a small quantity of zinc-blende and a little iron-pyrites, in a gangue of white translucent, occasionally transparent, quartz. The gangue amounted to 59·5 per cent., by weight, of the whole. Weight of specimen, eight and three-quarter ounces. It was found to contain:—

Gold............ distinct traces.
Silver........... 2·917 ounces to the ton of 2,000 lbs.

92.—From the "Silver King Mine," McCulloch Creek, Big Bend, Columbia River.

Galena, associated with a small amount of specular iron, in a gangue of white translucent quartz; the latter contained numerous cavities holding hydrated peroxide of iron, and was also, in parts, stained with this latter. The gangue amounted to 88·5 per cent., by weight, of the whole. Weight of specimen, four and a-half ounces. Assays showed it to contain:—

Gold........... distinct traces.
Silver.......... 21·875 ounces to the ton of 2,000 lbs.

93.—Said to have been collected at a point five miles east of Laporte, Columbia River. Vein twenty-seven feet wide. Gold and Silver Assays, cont.

A white sub-translucent quartz, thickly coated with hydrated peroxide of iron; a certain proportion of the latter, in a loose pulverulent form, also accompanied the specimen. Specks of metallic gold were readily discernible in the loose material. Weight of specimen, four ounces. It contained:— Province of British Columbia, cont.

Gold...........	40·542 ounces to the ton of 2,000 lbs.
Silver..........	0·700 of an ounce " "

94.—From Hixon Creek, Upper Fraser River, Cariboo District. Taken from a depth of one hundred feet. Examined for J. Reid, Esq., M.P.

It consisted of a white sub-translucent quartz, carrying copper-glance, a small quantity of copper-pyrites, a little galena, and trifling amounts of bornite and iron-pyrites. It was in parts stained with hydrated peroxide of iron, as also, here and there, with a little green carbonate of copper. Weight of specimen, three and a-quarter pounds. Assays showed it to contain:—

Gold.......	0·583 of an ounce to the ton of 2,000 lbs.
Silver......	29·983 ounce " " "

95.—The foregoing was accompanied by a small quantity—0·2332 gram—of material, which was stated to be the concentrates of half a pound of the rock. In this native gold was readily discernible. It contained:—

Gold	2·659 per cent.
Silver	4.181 "

96.—Subsequently another sample of concentrates of the ore from Hixon Creek (Assay No. 94) was received for examination; it weighed five and three-quarter ounces. Assays showed it to contain:—

Gold, equal to	8·021 ounces to the ton of 2,000 lbs.
Silver, "	18·229 " " "

of concentrates. It was not stated how many tons of ore a ton of such concentrates would represent.

97.—From the property of the Nicola Milling and Mining Company—south-east side of Stump Lake, Nicola Valley. Examined for Mr. A. E. Howse.

It consisted of galena in association with tetrahedrite, small quantities of iron-pyrites, copper-pyrites, and a little bornite, in a

Gold and Silver Assays, cont.

Province of British Columbia, cont.

gangue of quartz, the latter frequently very much honeycombed. The whole presented a more or less weathered appearance, and was for the most part coated with hydrated peroxide of iron, in parts with carbonate of lead, and here and there with a little green carbonate of copper. Weight of specimen, three pounds three and a-half ounces. Assays gave:—

Gold......	0·729 of an ounce to the ton of 2,000 lbs.		
Silver.....	104·271 ounces	"	"

98.—This, and the following specimen, is from the southern extremity of Stump Lake, Nicola Valley. They were examined for Mr. R. Scott.

A fine crystalline galena, associated with a little iron-pyrites, in a gangue of greyish-white translucent quartz. The metallic sulphides constituted, approximately, one-fourth, by weight, of the whole. Weight of specimen, three and a-half ounces. It was found to contain:—

Gold.......	0·729 of an ounce to the ton of 2,000 lbs.		
Silver......	15·094 ounces	"	"

99.—A somewhat coarse crystalline galena, in association with iron-pyrites, copper-pyrites, and a white translucent quartz; the latter constituted but a very small proportion of the whole. Weight of specimen, three and a-quarter ounces. Assays showed it to contain:—

Gold...........	1·969 ounces to the ton of 2,000 lbs.			
Silver..........	17·063	"	"	"

100.—From the Taylor lead, Big Bend, Columbia River. This and the three following specimens were examined for Dr. G. T. Orton.

A milky white quartz carrying a trifling amount of galena and iron-pyrites: it was in parts stained and coated with hydrated peroxide of iron. Weight of specimen, five and a-quarter ounces. It was found to contain:—

Gold........	0·175 of an ounce to the ton of 2,000 lbs.			
Silver.......	0·641	"	"	"

101.—From the Little Bunting lead, Big Bend, Columbia River. A white translucent quartz, with which was associated a litle mica; it was for the most part coated with ferric hydrate. Weight of specimen, two ounces. Assays gave:—

Gold............	1·925 ounces to the ton of 2,000 lbs.	
Silver...........	0·175 of an ounce "	"

102.—From Otter Tail Creek. Gold and Silver Assays, cont. Province of British Columbia, cont.

An association of a fibrous, finely crystalline, and a somewhat coarsely crystalline galena, through which was disseminated a few specks of copper-pyrites and a trifling amount of a micaceous mineral which gave all the reactions of Cookeite (see under Miscellaneous minerals, p. 12T); it was in parts coated with carbonate of lead. Weight of specimen, two and a-quarter ounces. It contained :—

Gold.......... none.
Silver......... 16·771 ounces to the ton of 2,000 lbs.

103.—From Otter Tail Creek.

An association of galena and tetrahedrite, together with a little copper-pyrites and quartz; it was, here and there, coated with carbonate of lead, and green and blue carbonate of copper. A small quantity of the micaceous mineral, referred to in describing the preceding specimen, was also observed in this one. Weight of specimen, three-quarters of an ounce. Assays showed it to contain :—

Gold.............. none.
Silver............ 113·749 ounces to the ton of 2,000 lbs.

104.—This, and the following specimen, is from the Columbia claim, McCulloch Creek, Big Bend, Columbia River. They were examined for Mr. R. A. McVitty.

From the North lead.—A white translucent quartz, carrying a little galena; some pieces were very much honeycombed, the cavieties holding hydrated peroxide of iron; all the fragments were more or less stained with the latter. Weight of specimen, four and three-quarter pounds. It contained :—

Gold........... distinct traces.
Silver.......... 16·975 ounces to the ton of 2,000 lbs.

105.—From the South lead.—A white translucent quartz, seamed and stained with hydrated peroxided of iron; it contained a little iron-pyrites. Weight of specimen, two pounds two ounces. Assays gave :—

Gold........ none.
Silver....... 0·525 of an ounce to the ton of 2,000 lbs.

106.—From thirty-three miles east of Revelstoke (formerly Farwell), near the line of the Canadian Pacific Railway, Selkirk Range. Examined for Mr. A. F. McKinnon.

Gold and Silver Assays, cont.

Province of British Columbia, cont.

A fine to moderately coarse crystalline galena, in association with a little calcite. It was found to contain:—

Gold............. none.
Silver............ 53·230 ounces to the ton of 2,000 lbs.

107.—From the Maple-leaf claim, Illecillewaet River, about thirty-three miles east of Revelstoke (formerly Farwell), and within a mile of the line of the Canadian Pacific Railway, Selkirk Range. Examined for Mr. J. Boyd.

A coarse crystalline galena, through which was disseminated a trifling amount of gangue, consisting of calcite; it was, in parts, stained with a little green carbonate of copper. Weight of specimen, ten ounces. It contained:—

Gold...........none.
Silver.......... 65·625 ounces to the ton of 2,000 lbs.

108.—From the Shamrock claim, which is in close proximity to the claim whence the preceding specimen was taken. Examined for Mr. J. Boyd.

Galena, exhibiting a somewhat fibrous structure, in asssociation with a little calcite; the latter constituted but a very small proportion, by weight, of the whole. Weight of specimen, one and a-quarter pound. Assays gave:—

Gold............ none.
Silver........... 78·750 ounces to the ton of 2,000 lbs.

109.—This, and the following specimen is from within three miles of Field Station, on the line of the Canadian Pacific Railway, Kicking Horse Pass, Rocky Mountains. They were examined for Mr. G. B. Pattee.

A moderately coarse crystalline galena in a gangue of dolomite. Weight of specimen, four pounds three ounces. The galena, carefully freed from the gangue, was found to contain:—

Gold............ none.
Silver........... 3·646 ounces to the ton of 2,000 lbs.

110.—A fine to moderately coarse crystalline galena. It contained but a very trifling amount of gangue. Weight of specimen, two pounds two ounces. Assays showed it to contain:—

Gold............ none.
Silver............ 6·563 ounces to the ton of 2,000 lbs.

111.—From Goat River, Kootenay. Received from Mr. J. W. Ridgway.

A fine to moderately coarse crystalline galena in association with a little iron-pyrites, in a gangue of quartz. Weight of specimen, fifteen ounces. It contained:—

Gold and Silver Assays, cont. Province of British Columbia, cont.

Gold............	none.
Silver...........	14·583 ounces to the ton of 2,000 lbs.

112.—From the Steadman ledge, Richfield, Cariboo District. Examined for J. Reid, Esq., M.P.

A white translucent quartz, traversed by thin seams of carbonaceous matter, with, here and there, a few specks of iron-pyrites. It was found to contain:—

Gold..............................	distinct trace.
Silver	none.

113.—From the Ebenezer Mine, Kicking Horse Pass, two and a-half miles east of Golden City, Rocky Mountains. Collected by Mr. R. G. McConnell.

A white, fine crystalline-granular limestone, through which was disseminated small quantities of a bright-red colored cinnabar and minute crystals of iron-pyrites. Assays showed it to contain:—

Gold	trace.
Silver	none.

MISCELLANEOUS EXAMINATIONS.

Miscellaneous examinations.

1.—Shell-marl from the Island of Anticosti, Province of Quebec. Examined for Mr. F. W. Stockwell.

Shell-marl from the Island of Anticosti, Province of Quebec.

This material was found by Mr. F. D. Adams to contain—after drying at 100° C., whereby it lost 20·897 per cent. of water—0·008 per cent. of phosphoric acid, which would represent 0·017 per cent. tribasic phosphate of lime. Or—in the condition in which it was received—0·0063 per cent. of phosphoric acid, representing 0·0137 per cent. tribasic phosphate of lime.

2.—A carbonaceous schist from one mile south of Ptarmigan Bay, Lake of the Woods, District of Keewatin. Collected by Mr. A. C. Lawson.

Carbonaceous schist from Ptarmigan Bay, Lake of the Woods, District of Keewatin.

It had a blackish-grey color, was fine-grained, and earthy in texture. Mr. F. D. Adams found it to contain—after drying at 100° C., whereby it lost 0·094 per cent. of moisture—5·773 per cent. of carbonaceous matter.

Cement-stone, from vicinity of Calgary, North-West Territory.

3.—Cement-stone. From Shagganappi Point, about two miles west of Calgary, on the line of the Canadian Pacific Railway, North-West Territory. Geological position—Laramie.

A very fine-grained, bluish-grey limestone from this locality yielded, when calcined, a lime of very marked hydraulic character, setting under water in from four to five minutes, and soon acquiring a considerable degree of solidity.

Saline deposit, from vicinity of Maple Creek, North-West Territory.

4.—Saline deposit from the bed of a dried-up lake near Maple Creek, North-West Territory. Collected by Mr. R. G. McConnell.

Mr. McConnell states that the lake, which has an area of about one hundred acres, is annually filled in the spring, and dries up towards autumn; also that the saline deposit exceeds four feet in thickness.

This latter has been examined by Mr. E. B. Kenrick. A small proportion of the same was insoluble in water; this was composed of clay, sand and organic matter, and a little carbonate and sulphate of lime. The balance consisted almost exclusively of sulphate of soda, with a little sulphate of magnesia, and a small quantity of chloride of sodium.

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ABBREVIATIONS.

Al.	District of Alberta.	N.W.T.	North-West Territory.
B.C.	British Columbia,	O.	Province of Ontario.
Ma.	Manitoba	Q.	Province of Quebec.
N.B.	New Brunswick.	Sk.	District of Saskatchewan.
N.S.	Nova Scotia.	V I.	Vancouver Island.

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